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A View Down a Creek Bed Showing the Destruction Caused in Forest Country. The Bridge Is Typical of the Temporary Structures Built in Such Locations. The Piers Are Studs Resting on Large Logs Buried in Slip Material

HIGHWAY RECONSTRUCTION
Through Earthquake Shattered Mountains

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ON June 17, 1929, a serious earthquake occurred in the northwest of the South Island of New Zealand, reaching intensity 10 on the Rossi-Forel scale in the mountainous country between Murchison and the coast. Two highways passed through the zone of maximum intensity and suffered considerable damage, and were not reopened for through traffic until some 18 months later. Secondary roads also suffered but as none of them extended far into the mountains the damage was not comparable with that on the two highways. Though some six years have now elapsed, trouble is still experienced with the slips and, as earthquake slips differ in some respects from the normal variety, some notes on the subject may be of interest.

In undulating country the effects of a major earthquake are mostly apparent in damaged structures, fissures, sand boils and subsidences of made ground. In rough country, on the other hand, the results are cataclysmic. In the 1929 shake mountain sides were riven asunder and rocks, trees and earth plunged down a 1,000 ft. into the rivers below, forming dams whose crests, in some instances, were over 100 ft. above the original stream bed. On the coast north of Mokihinui (see sketch map), where the narrow coastal plain ends in cliffs 500 ft. high, a block of 90 acres was lifted an average height of 80 ft. The Westport-Karamea Highway between the Mokihinui and Little Wanganui Rivers was a series of gigantic land slides, while from thence northward 8 miles of road was abandoned and a deviation made along the coast. Near Karamea the land had sub-

Sketch Map Showing Location of Highway Reconstruction

sided, the highway was inundated at high tides, and 2½ miles had to be raised from 3 to 4 ft.

Karamea is a fertile farming district lying between the mountains and the sea and also produces considerable quantities of timber. Access therefore was of extreme importance but fortunately the bulk of the produce could be shipped by scow from the Karamea and Little Wanganui Rivers. The average traffic on the highway was only in the neighborhood of 30 motor vehicles per day.

Reconstruction Undertaken as Relief Measure.—At that time the fall in world prices for farm produce, upon the export of which the Dominion chiefly relies for her prosperity, was just beginning to be felt and unemployment was starting to appear. The government therefore decided that reconstruction should be undertaken as a relief measure and funds were made available for the work to be carried out on this basis by the Public Works Department. Canvas camps were established along the 22 miles of badly shattered road and first linked up by a narrow pack track, making use of any short lengths of old road undamaged. This was then widened to provide a minimum formation width of 16 ft. with a 14 ft. gravel surface.

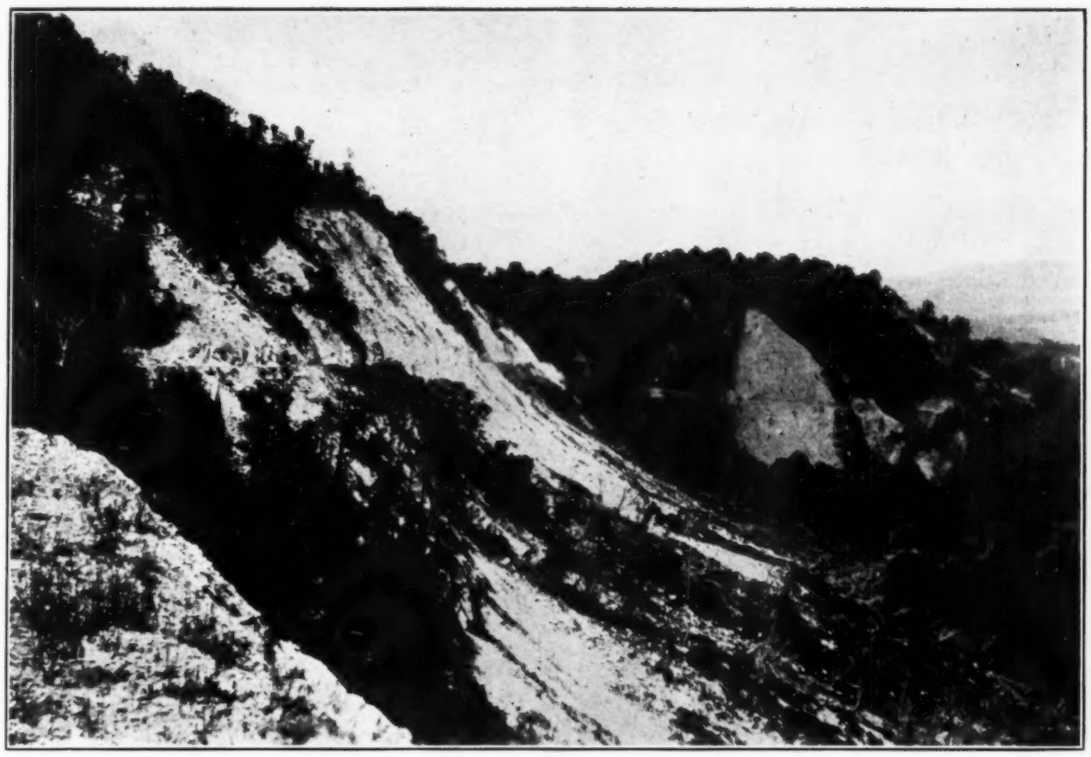
Owing to the nature of the work the turnover in labor was rapid on account of men being reabsorbed into their old occupations, but the numbers engaged were maintained fairly constantly at between 300 and 400 until the reconstruction was nearly completed. As every rain brought down fresh slips a large maintenance force was necessary for some years and, when not clearing debris, these men completed the culverting and graveling of the new road. As the slips began to consolidate this force was reduced until, by 1933, a gang of 10 men, assisted by temporary recruits in times of stress, was able to take care of the 22 miles.

Similar conditions prevailed on the Westport-Nelson Highway over the 30 miles of the Upper Buller Gorge between Inangahua and Murchison but in the Lower Gorge between Inangahua and the coastal plain damage was restricted to minor slips and sunken fillings. This was due to the lower intensity of the earthquake in this area—about 8 on the Rossi-Forel scale. Reconstruction was undertaken in a similar manner to that on the Westport-Karamea Highway and opportunity was taken to make some desirable relocations to improve grades.

Damage to Bridges.—Fortunately most of the bridges escaped serious damage. One single span concrete structure opened up and dropped the deck into the stream between the abutments and several bridges were buried by slips while others were so wracked and twisted that complete renewal was required. In all nine bridges from 20 to 240 ft. in length had to be replaced. Five of these bridges were over streams actually running through slips and, as the sites were unstable, only temporary spans costing about $10 per foot were erected. Three of the original bridges in these locations carried away at various times during heavy rain owing to general movement of the slips but at two sites conditions have become sufficiently stable for the erection of more permanent structures.

Causes of Slips.—Normally the surface of the ground establishes itself, under the influence of weathering, at a stable slope. At times works carried out by man disturb the natural equilibrium either by the removal of

Konini Slip from 80 Ft. Above the Road Looking Down the Gulch



Slips in Limestone Country, Westport-Karamea Highway

vegetation promoting more rapid weathering or by earthworks which exceed the angle of repose of the material or allow the ingress of water to planes of weakness. There are also areas, geologically young, which have not yet acquired stability of outline and which slip during heavy rainfall or run-off of snow waters. Mountain tops with their shingle slides are included in this category.

Other than the exceeding of the angle of repose of the material, as, for example, in a cut through a sand dune, water is the cause of all slips normally encountered. It either reduces the angle of repose of the material or it seeps through to impervious strata or "greasybacks," along which movement is induced by the lowering of the coefficient of friction. If the source of this water can be located and the slip drained the trouble is usually ended.

How Earthquake Slips Are Formed.—Earthquake slips are formed in three ways: (1) Fissures allow water to enter, either from the surface or from subterranean channels and a slip of the normal type is produced. (2) The shattering of the crust due to the bending stresses set up by the earthquake waves as they travel along the surface. This shattering action is, of course, chiefly met in rock country which is converted from a solid into a granular material having a considerably flatter angle of repose than the original rock. (3) Movement occurs along fault planes often accompanied by the shattering of the rocks along the fault, giving rise to subsidiary slips of type (2).

Condition of Westport-Karamea Highway.—The mountainous portion of this route was mostly through an argillaceous limestone which was everywhere extensively broken and crushed, particularly in the direction of the dip of the strata. On the scarp sides of the ranges falls were smaller and usually consisted of large boulders. Konini Creek, the most troublesome slip in this length, though actually one of the smallest, lies on an old fault

Another View of Konini Slip. Arrows Indicate Position of Road

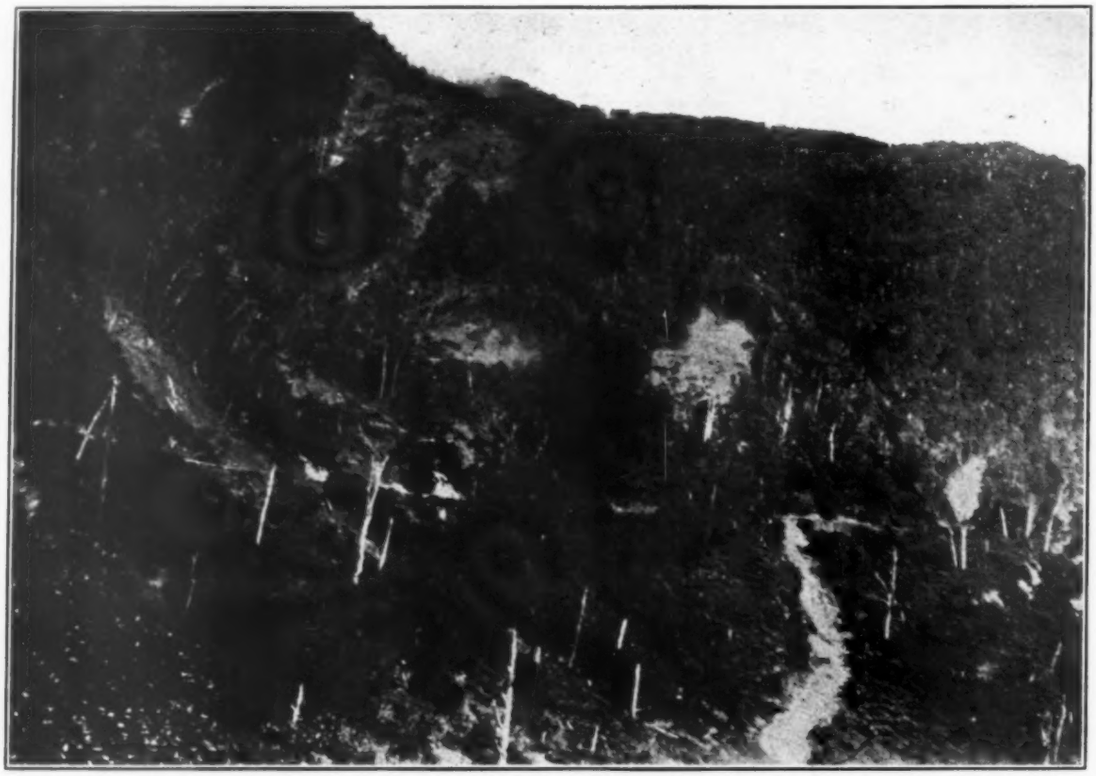
An Earthquake Dam in the Mokihinui River Which Was Cut Down 100 Ft. When Over Topped by Backed Up Water and Caused a Serious Flood in the Valley Below

where the limestone adjoins a granite. The granite horizon at some earlier date was thrust over the more recent limestone and an unconsolidated friction breccia of metamorphosed granite overlies the limestone for a distance of 14 miles along the road and formed a continuous succession of jumbled limestone and granite slips effectively burying the road over the whole distance.

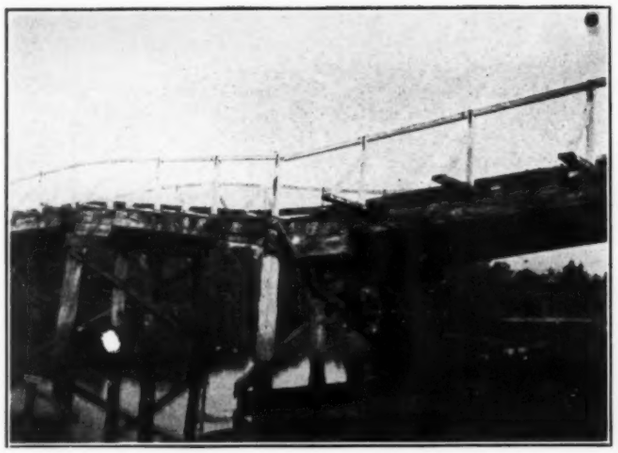
Conditions on Westport-Nelson Highway.—The damaged length of this highway was in granite country near the old quartz mining township of Lyell. Stresses set up by the earthquake waves caused the disintegration of the granite into coarse sand interspersed with boulders and man-size stone. The locality was traversed by a fault on which vertical displacement varying between 1 and 18 ft. occurred over a distance of 10 miles. Where the fault crossed the road there was a vertical displacement of 14 ft.

The highway carried 45 motor vehicles per day, 50 per cent being light truck traffic, and, by forming several short lengths to join up existing county roads, it was possible to provide a detour skirting the badly damaged areas but entailing an increase in distance of 38 miles. During the reconstruction period traffic of this route was considerably reduced, but with the reopening of the highway and later with the improvement in the Dominion's finances, the amount of traffic was greatly increased, particularly during the summer tourist season.

Treatment of Slips.—Stable conditions through these slips could only be obtained by flattening the batters. When one considers that many of the slips extended up mountain sides for over 500 ft. above the grade line and that all the material was alive, the magnitude of the task will be realized. The method of attack was first to open up a pack track about 2 ft. wide along the grade line to give access over the whole length. This was then widened by taking out the toe and allowing the material higher up to fall. This sounds dangerous but, before work was started on the toe, men were slung on ropes



The Regeneration of Forest Growth in Limestone Country Helped to Consolidate Slips. View Taken About 5 Years After Earthquake



A Timber Bridge with Piers Tilted and Thrown Out of Alignment. This Type of Damage Occurred Chiefly in Recent Deltaic and Unconsolidated Sedimentary Formations

over the slip faces and the larger boulders barred out while the tangled masses of trees were cut up and rolled down into the gorges below. In addition lookout men were employed for every gang to give warning of any movement above them. During dry weather the working places were moderately stable but with rain the taking out of a small quantity of material at the grade line started movement in considerably greater quantities above, most of which traveled down across the road with no further effort. The road itself often disappeared with the avalanches from above, it is true, but this was more of a help than otherwise for a road founded on

Earthquake Fissures in a Fill Crossing a Tidal Swamp. Subsidence of the Ground Allowed High Tides to Wash Over the Road

such unstable material would be a menace. During heavy rain when most of these large slips occurred the work was not manned.

In time a fairly stable batter was achieved but weathering influences are still bringing down slips, though each year the trouble is lessened. The causes of these slips are:

(1) Run-off over the surface of the slip erodes large quantities of fine material and reduces the stability of the larger stones on the face. The fine material is particularly troublesome as it blocks the side ditches and turns the water onto the roadway.

(2) Water percolating through the open slip material reduces the angle of repose.

(3) Frost heave loosens larger stones which ultimately fall bringing other debris down with them. None of the highways are subjected to snow conditions, but the rainfall, fairly evenly distributed throughout the year, is between 85 and 100 in. per annum.

Owing to low traffic density a blockage for a few hours, or even for an occasional day, is permissible and it has been more economical to allow nature to carry on with the flattening of batters than to have trimmed back all slopes when reconstruction was in progress. The slips too are consolidating with the progress of time and the regeneration of forest growth is preventing surface erosion. This regeneration is of the greatest importance

The New Road Formed Through a Small Slip

and on limestone country is proceeding satisfactorily but in granite country it is, as yet, negligible.

Konini Slip.—This slip, though particularly troublesome, is typical of the difficulties encountered and the expedients employed. The slip itself is only a small one and, in plan, covers 14 acres. It is situated on a fault which, just below the road, forms a narrow rock-sided gulch, along both sides of which the road is formed with a sharp semicircular curve where it crosses the slip at the head. Above the slip the road opens out into a horseshoe shaped ampitheatre extending to an elevation of 850 ft. above the road. The rainfall in the locality is over 100 in. per annum and during rain mud and boulders move down with a glacier-like motion and are concentrated by the rock gulch into a length of less than 200 ft. of road. The mass then travels down at a gradually decreasing slope to an elevation of minus 700 ft. below the road and there spreads out over the valley floor. Investigations were made with a view to bringing water in at the top and sluicing all the material off the face. Owing to the elevation, however, this was not feasible.

A Section of the New Road on the Westport-Nelson Highway Showing the Sharp Curvature Necessary in the Upper Buller Gorge

The road itself, where it crosses the gluch, is formed on slip material and though crib logging has given temporary relief, particularly when the road has been timbered to act as a flume when passing debris, an exceptionally heavy rain will carry everything away. The road at this point is on a 6 per cent grade so that a suspension bridge across the gulch where solid rock appears is not possible owing to shortening of distance. No stable foundation is available for a bridge nearer the slip and, for the same reason, a structure of the snow shed type is also out of the question. Water only flows out of the slip during wet weather but the most satisfactory method so far discovered of clearing debris off the road has been by building small dams and using the water to hand sluice the material across the road as it falls.

Labor Organization.—The work was carried out by hand labor methods on a co-operative contract system under which the Department supplied tools and camps and the men were split up into small gangs and allotted short lengths of formation. Payment was made per cubic yard at prices agreed upon between the men and the Department engineers so that an ordinary laborer could average 14 shillings ($3.50) per day of 8 hours. Actual earnings of the various gangs varied between $3 and $4, some gangs making as much as $5. At this time 14 shillings was the standard rate for common labor in country districts where accommodation, but not messing, was supplied. The completion of the work could possibly have been hastened by the use of power shovels but these could have only been used to a limited extent owing to the difficulties of transport. Power equipment of this type is not as economical in New Zealand as in the United States. Costs of plant and fuel are considerably higher while wages are lower, necessitating a very careful comparison of the factors making up the cost of moving a cubic yard before power shovels are decided upon. In this instance the cost of getting shovels onto the job and the likelihood of their being frequently buried by slips decisively swung the scales in the favor of hand methods. It was this item which made the work so suitable for an unemployment relief project. Nevertheless every opportunity was taken to use the forces of nature to achieve the desired object, i.e., the flattening of batters, instead of doing the work by hand.

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Eliminating Slippery Surfaces on Steep Granite Block Street

A slippery surface on a rough old granite block pavement on a 15½ to 17½ per cent grade at Tarrytown, N. Y., was eliminated by the use of cement mortar.

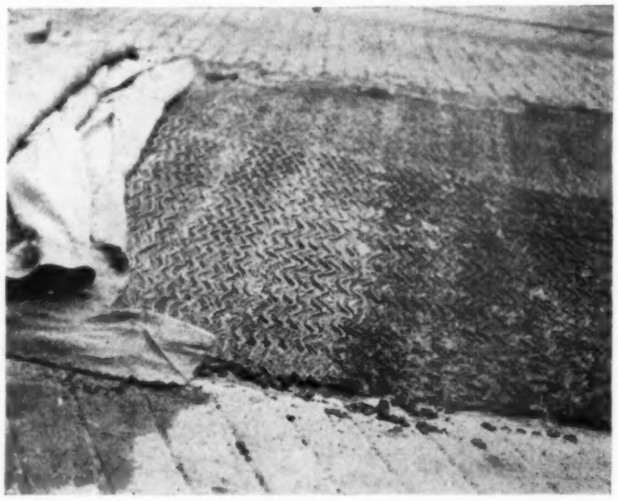
Before proceeding with the entire project, which included an area 18 by 600 ft., a small sample of the proposed treatment was applied and the results were so convincing that the entire project was given the same treatment.

Treatment was very simple, consisting of applying a 1:1½ sand-cement mortar approximately ¼ in. thick over the surface of the granite block. The granite block was first cleaned thoroughly. The mortar was made with high early strength cement and regular Long Island sand, rather coarse, with 4½ to 5½ gal. of water per sack of cement.

The mortar was mixed by hand in a box and deposited with wheelbarrows. It was immediately broomed over the surface of the granite block, which previously had been thoroughly wet down with a hose. The mix had no tendency to run down the stiff grade on which it was applied.

Method of Brooming Mortar Surfacing Over Granite Block

As soon as the uniform thickness of mortar had been spread over the surface of the block, it was roughened with a stiff wire broom drawn across the surface with a wavy motion. The mortar was then covered with a double thickness of wet burlap which was kept wet for



Scored Mortar Surfacing

72 hours. The result was a thoroughly satisfactory driving surface in place of a dangerous incline.

The total cost of the work is given by T. A. Avery, Division Engineer of the Westchester County Engineers Office, as $70 for 1200 sq. yd. The crew on the job consisted of a foreman and 6 men, untrained in cement work. Equipment required was a truck, a wheelbarrow, a mortar box, hand mixing equipment and brooms.

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BUREAU OF ROADS OF GUATEMALA MILITARIZED.—President of Guatemala has militarized the Bureau of Roads, with control being vested in the Ministry of War. The Director General of Roads will be the Chief of the Corps, presumably with the rank of full colonel or brigadier general, while other officials and employes will be granted military rank as follows: Engineers (majors); inspectors (captains); mechanics (first lieutenants); road supervisors (second lieutenants); chauffeurs (sergeants); and foremen (corporals).

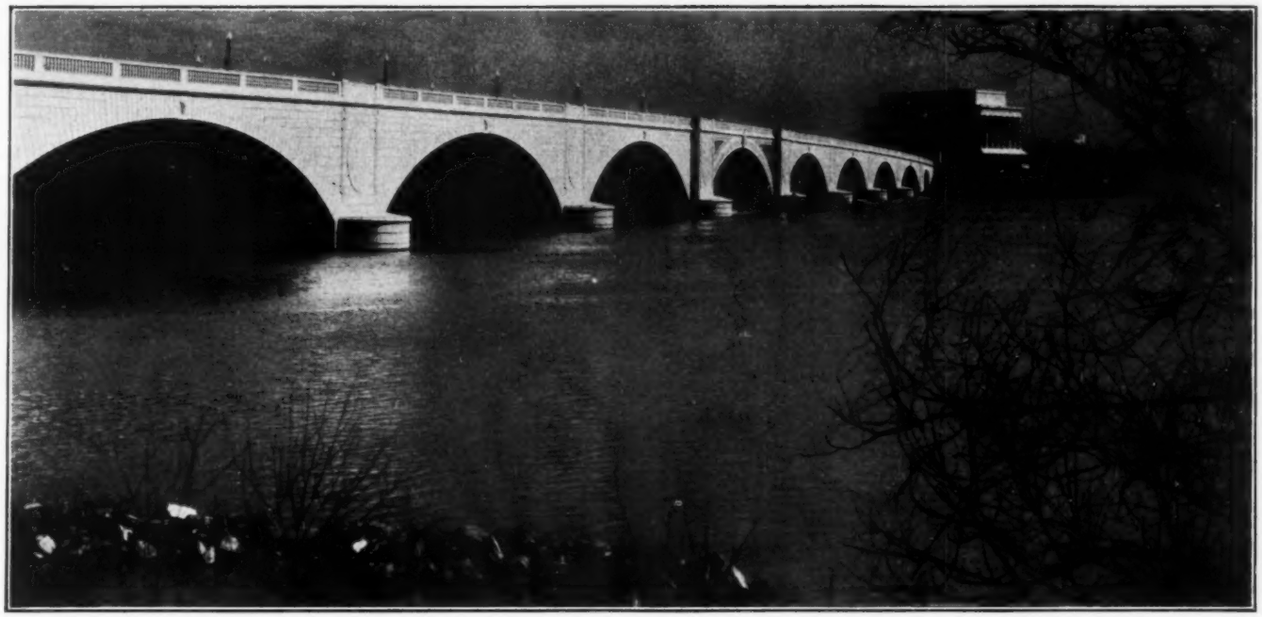

Photo by Courtesy U. S. Bureau of Public Roads

The Memorial Bridge, One of the Important Crossings Over the Potomac at Washington, to Which the Lee Boulevard Will Be the Main Connection for West Bound Traffic

THE LEE BOULEVARD OF GRAVEL AT ITS BEST

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Senior Highway Engineer Division of Construction, U. S. Bureau of Public Roads

ONLY a few years ago engineers considered gravel a temporary surfacing, to be used on a well traveled road only until a better could be applied, or to be used more permanently on light traffic roads. But this view is changing. A gravel surface is no longer treated wholly as a temporary expedient or as a means of keeping light traffic out of the mud. That view is out of date. In its place an appreciation is developing of the fact that gravel, if rightly used, may be made to carry a great deal of traffic over a quite satisfactory period. For this reason special interest attaches to the recently constructed Lee Boulevard, a four lane surface treated gravel highway extending from a point just west of Falls Church, Virginia, to Fort Myer, Virginia, and shortly to be extended to a connection with the nationally famous Memorial Bridge across the Potomac River at Washington. The fact that this boulevard has been constructed as a four lane highway speaks volumes as to the traffic it is expected to carry. Most of this traffic will, no doubt, move in automobiles. Little truck traffic is expected. Still, the fact that a surface treated gravel has been used emphasizes the importance of comment on the considerations and the technique which have made this a reasonable thing to do.

Causes of Changes in Status of Gravel.—The change which is taking place in the status of gravel as a surfacing material is partly the result of wider experience in its use, but is more definitely the result of changes which have taken place in the tires with which heavy motor vehicles are equipped. When heavy loads were hauled in steel tired vehicles and later when the much larger and faster moving trucks equipped with solid tires were in common use, the impact loads generated by these vehicles were so high that they caused a considerable amount of internal movement in traffic bound surfaces. This internal movement was a movement under heavy load. That is, the forces that caused it were of considerable magnitude and when movement occurred, it oc-

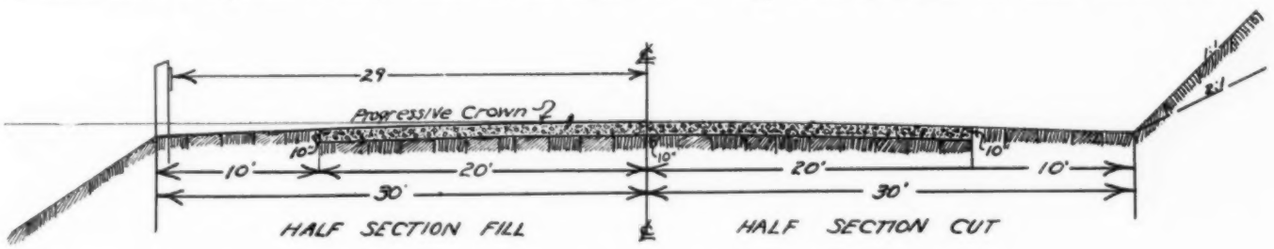

Fig. 1.—Typical Section of 40 Ft., 10 In. Gravel 60 Ft. Roadway

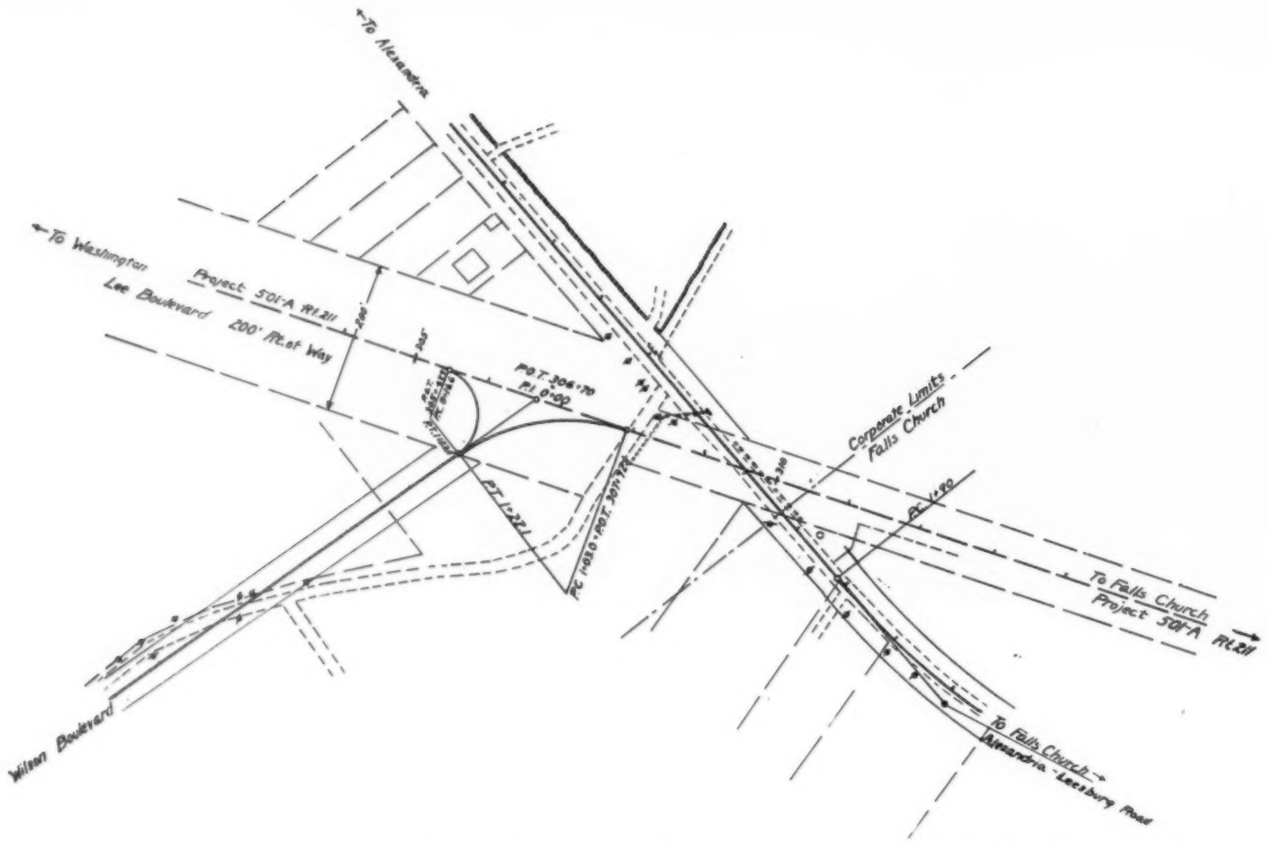

Fig. 2.—An Important Intersection on the Lee Boulevard. High Banks Have Been Cut Back to Give a Clear View in all Directions

curred in the face of definite resistance. The result was so much internal wear that the pebbles in a gravel surface often were literally ground into powder. Surface treatments, even the heavier surface coverings, failed to prevent this internal wear. The concentration of traffic loads under steel tires and under solid rubber tires was great and these relatively thin layers could not much distribute it. Internal wear went on under them about as it did where they were not used.

Pneumatic Tires Eliminate Impact Loads.—But in the very nature of the case, impact loads are all but eliminated when pneumatic tires are used. The gradual abandonment of solid tires which has been taking place during the past five years—an abandonment toward which the researches of the Bureau of Public Roads have contributed very materially—has, then, greatly reduced the strain on road surfaces—the impact loads to which they are subjected. A little impact still remains, it is true, but it is trifling as compared with the impact loads that were common when solid tire vehicles were used. In point of fact, so little impact is developed by pneumatic tires that the rolling loads of today are only moderately in excess of the static loads developed by the dead weight of the loaded vehicles which use the highways. These loads are often fairly heavy but they are not heavy enough to develop much of any internal movement or much internal wear in a properly constructed traffic bound surface. The result is that, under modern traffic, a well constructed gravel surface covered by a bituminous mat, or better wearing surface, has become a fairly permanent type of construction as well as a type capable of carrying a very considerable volume of traffic, even of heavy traffic.

Errors of Construction Cause of Failures.—It may be objected that there still is a good deal of evidence of the failure of gravel surfaces under traffic and that the number of such failures is sufficient to call the above statement into question. At first glance, this would appear to be the case. But, on closer examination, it will usually be found that the conspicuous failures of gravel surfaces are the result of errors in the manner of the construction of these surfaces which have caused them to fall an easy prey to the adverse influences widely prevalent in the late winter and early spring. These are easy to locate.

The gravel surface is a surface in which the body of the pavement is composed of natural pebbles. The stability of such a pavement depends on point and line contacts between pebbles, these contacts being maintained and the rearrangement of the pebbles prevented by a binder which should be present in such volume as to fill the voids between the pebbles. The usual binder is a combination of sand and clay.

From this quite general statement it should be evident that to secure the greatest amount of natural stability in a gravel surfacing, the volume of the compacted gravel in it should be equal to the total volume of the surfacing, or to state the matter a little differently, every cubic foot of the surfacing should contain a full cubic foot of gravel. If this is not the case, and very often it is not, the pebbles in the surfacing are not in as full contact as a maximum stability would dictate. Where there is less than a full cubic foot of compacted gravel in every cubic foot of the compacted surfacing, it is evident that the binder not only fills the voids in the gravel but serves to hold more or less of the gravel particles somewhat apart. The result is that, to a corresponding extent, line and point contacts between the gravel particles are replaced by bearings on the binder. In dry weather, this is not objectionable as the bearing power

The Intersection Shown on Fig. 2. Area in Foreground Was a High Bank Which Has Been Removed to Give Clear View. Intersecting Road Is Alexandria-Leesburg Road. Other Road to Left Is Wilson Boulevard

of clay and of sand clay mixtures is quite sufficient to produce a satisfactory degree of stability in the road surface. But in wet weather and during spring thaws, stability is likely to be lacking. At such times the clay in a gravel surfacing is wet. Wet clay is plastic. Then, if some of the gravel particles bear on the binder rather than on other pebbles, the clay in the binder having lost a considerable part of its stability, the pebbles which rest on the binder lose a considerable part of their support. The inevitable result is that those near the surface move under rather light loads. Under heavier loads, this movement may—often does—extend to the bottom of the surfacing and even into the subgrade. It is, of course, quite evident that in any structure like that of a gravel surfacing, the displacement of one particle is likely to cause the displacement of others. In practice, then, an excess of binder is pretty likely to render the whole surfacing somewhat unstable whenever conditions are such that this binder is deprived of any considerable part of its ordinary bearing power. This may occur as a result of protracted wet weather. It is more likely to be the result of frost action. In either case, if the result is a wet and consequently a soft binder and there is too much binder in the surfacing, the surfacing will lack stability and may break up.

The ideal binder for a gravel surfacing is a mixture of sand and clay in which the clay content fills the voids in the sand and the sand-clay combination fills the voids in the gravel. Such a surfacing, once compacted, is reasonably stable even in wet weather and while frost action may open it up a little, it does not become really unstable even as a result of frost action, as a gravel surface is pretty certain to do if it contains so much of a surplus of clay binder that a material fraction of the pebbles are bedded on the binder. The stability that is being built into modern gravel highways, of which the Lee Boulevard is an outstanding example, is based on a recognition of these principles.

While these matters are always of importance, they are particularly so when the surfacing is to carry a mat top. Instability in the material underlying the mat results in the rapid destruction of the mat and while such mats must, in any event, be renewed at rather frequent intervals, any instability in the material lying under them increases the cost of their maintenance and the frequency with which they must be renewed. Both are expensive.

Design Features of Lee Boulevard. — The design of the Lee Boulevard is not only interesting because of the use on it of gravel as a surfacing but because of several other design features which deserve more general adoption. One of these is the absence of side ditches. There is no more archaic feature in modern highway design than the use of deep side ditches. Thousands upon thousands of cars are trapped every year in such ditches and require assistance in getting out. A good many cars are wrecked by running into such ditches. To avoid the use of ditches in cuts the shoulders along the Lee Boulevard are sloped lightly to the cut slope. Water carrying capacity is adequate, but under no circumstances can a car become entrapped because of the depth of the ditch or the steepness of its side slopes. As a matter of fact, these shoulders are so wide and slope so gently that they provide a much needed area which can be used without risk either in an emergency or if, for any reason drivers wish to stop along the highway. This is as it should be. Every modern highway of any importance should have a shoulder width that is wide enough to permit those who wish, for any reason, to stop for a time to do so without obstructing traffic.

This type of design has the additional advantage that it can be readily kept in proper condition by a blade grader. Of scarcely less importance is the fact that weeds and grass can, without the slightest difficulty, be

Lee Boulevard's Wide Shoulders; No Side Ditches to Entrap Cars

Intersection of Lee Boulevard and the Lee Highway (U. S. Route 211). Boulevard to Right

kept down by power mowers, a thing it is not altogether possible to do when the more ordinary shoulder and ditch sections are used.

Here a direct saving in the annual cost of upkeep is to be expected. All highway design should keep maintenance cost in mind. Much of this is for work on shoulders and slopes, for keeping these in condition, for keeping weeds cut and for keeping ditches open. The use of a section which lends itself to the efficient use of modern machines for performing the routine maintenance operations on the shoulders and the slopes, would have much to recommend it if it rendered no special service of any other kind.

Those who designed the Lee Boulevard have given much thought to safety. A wide highway always is relatively a safe highway because it offers a better view of cars approaching the highway from side roads. The wide shoulders which have been used increase the breadth of the view. But the designers did not stop here. All important intersections have been opened up, widened, and high banks cleared away to give a clear view in all directions.

The boulevard will be used for high speed travel. At 60 miles an hour one drives over it in perfect comfort and with a feeling of perfect safety because, in addition to the sense of security that lies in width, a long forward sight distance has been provided. There are no sharp curves. The few curves there are have been suitably superelevated.

All of these matters deserve consideration in the design of a modern highway but from the standpoint of safety none are more important than width and distance of vision. On this highway these seem safely to provide for high speed travel which is as it should be. After all, roads are built for those who use them and, should be safe at any speed the public really wishes to use. It is not enough that highways be made safe up to the speed at which engineers feel the public should drive. They should be made safe for speeds at which people do drive. This one has been.

High fills have not been altogether omitted but on the whole, the design of this highway gives the refreshing impression that a studied effort has been made to fit the highway to the ground over which it runs. Cuts give the impression that they were necessary, fills that they are the lightest consistent with good design. Every new highway tears up the country through which it runs. The question is not how much the countryside has been marred but whether, as time passes, the highway will merge into the balance of the landscape without seeming to be a defacing mark on it. Undoubtedly, this one will. And perhaps this is as great a compliment as can be given the engineer who locates and designs a highway. The one that so fits the country through which it runs that it creates the comfortable impression that it rightfully belongs where it was put, stands as a fitting monument to the fact that there is much art and much benefit from using it in even so prosaic a thing as putting a few miles of highway in the right place.

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Governmental Costs of 94 Cities Amounted to $2,464,319,602

According to a statement just issued by the Bureau of the Census the governmental costs of the 94 cities having a population of over 100,000, for the fiscal year ended Dec. 31, 1933, or for the latest complete fiscal year closing on a date prior thereto, amounted to $2,464,319,602; the aggregate revenue receipts were $2,506,723,973; and the total net indebtedness was $6,360,586,081.

The payments for operation and maintenance of the general departments of the city governments of the 94 cities for the fiscal period 1933 amounted to $1,727,042,682 or $46.08 per capita. In 1932 the per capita for operation and maintenance of general departments was $47.88, and in 1918, $21.47. Payments for the operation and maintenance of public service enterprises, as water works, electric light plants, and similar enterprises, amounted to $115,264,395; interest on debt, $355,016,375; and outlays for permanent improvements, including those for public service enterprises, $266,996,150. The total payments in 1933, therefore were $2,464,319,602.

The totals for the 94 cities include all governmental-cost payments for the year, whether made from current revenues or from the proceeds of bond issues.

Of the 94 cities covered by this report only 8 were lacking in revenues sufficient to meet all operating expenses and interest, while 60 realized enough revenues to meet all their payments for expenses, interest, and outlays and to have a balance available for paying debt.

Of the total governmental-cost payment in 1933, 70.1 per cent was for operation and maintenance of general departments; 4.7 per cent, operation and maintenance of public service enterprises, such as water-supply systems, docks, wharves, markets, etc.; 14.4 per cent, interest on debt; and 10.8 per cent, outlays for permanent improvements (public buildings, etc.).

Of the payments for operation and maintenance of general departments 32.5 per cent was for education; 17.3 per cent, protection to person and property; 16.9 per cent, charities, hospitals, and correction; 8.2 per cent, general government; 6.4 per cent, highways; 5.8 per cent, sanitation or promotion of cleanliness; 3.5 per cent, recreation; 2.3 per cent, conservation of health; and 7.1 per cent, miscellaneous.

With the exception of an increase of almost 4 per cent for charities, the percentages for 1933 show but little change from those for 1932, the largest in each of the years being for education and the smallest for conservation of health.

Of the total payments for outlays for permanent improvements, the principal items were $89,699,205, or 33.6 per cent, for highways; $26,843,100, or 10.1 per cent, for education; and $84,842,494, or 31.8 per cent, for public service enterprises.

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Two States Propose to Prevent Diversion of Gas Tax—Bills have been introduced in the legislatures of Maine and North Carolina requiring that all gasoline tax and license fee money collected from motorists be used for highway improvement and construction and nothing else.

Placing Aggregate on the Road in Uniform Windrow. Salvaged Material Scraped to Center and Covered by Windrow of New Aggregate

OIL-MIX SURFACES IN LIVINGSTON COUNTY, MICHIGAN

By W. J. SLAVIN

County Engineer,
Livingston County, Michigan

THE first mile of oil-mix road in Michigan was built in Gratiot County in 1929. The fact that this road surface could be built using cheap local aggregate was of special interest to us because we had an abundance of local gravel in the county, much of it being of a sandy nature. Maintenance of a loose gravel surface on our main county roads was becoming more difficult and expensive each year, and as the oil-mix type of surface seemed to fit in best with our local conditions, it was decided to give it a trial.

Two miles were built in 1930, using a 60 to 70 per cent asphaltic oil and bank run gravel. The roads selected for surfacing were main county roads leading into Howell carrying a traffic of about 700 vehicles per day. They had originally been surfaced with gravel to a 9 ft. width and 8 in. depth, but repeated resurfacing had widened the gravel to about 20 ft. The depth of the gravel at the outer edges, however, did not exceed 2 or 3 in. in some places.

The first year's experiment proved quite satisfactory in spite of the fact that part of the surface corrugated and had to be remixed with additional sand.

In 1931, we began using a 70 to 80 per cent asphaltic oil with the thought in mind that the higher asphaltic content would produce a more durable surface and one which would be less subject to damage by moisture. This proved to be correct and the use of the lighter oil was discontinued.

The work done in 1932 was similar to that of 1931, except that more attention was given the grading of the aggregate. Sieve tests showed that the gravel that we had been using was deficient in fine material. This had been the cause of some raveling in part of the previous year's work, so we began adding from 5 to 10 per cent of the finest sand obtainable locally. This increased the density of the aggregate and made a more stable surface which did not corrugate nor ravel.

In 1933, we surfaced about four miles road using several different grades of cut-back asphalt and tar in the mix instead of oil. The grading of the gravel was similar to that used in regular oil-mix work. We used some rapid curing cut-back made of 60-70 penetration asphalt. This material set up a little too fast and for that reason was rather hard to mix with the fine aggregate.

We also used a somewhat slower curing cut-back made of 70-85 penetration base asphalt. This material mixed more easily with the aggregate and made a quite hard surface which is standing up well.

A medium tar was used on about one-half mile of road and is quite satisfactory.

Another material which we found very satisfactory was medium curing cut-back which is designated by the Asphalt Institute as MC-2. This material was made from about 150 penetration asphalt cut-back with a slow evaporating solvent such as kerosene. It mixes with the aggregate quite easily and in about thirty days the surface hardens enough so it is not damaged by ordinary tractor lugs. When using cut-back asphalt and tar, we used 0.58 gal. per square yard per inch of loose aggregate.

We do not think that a bituminous material harder than 100 penetration asphalt should be used in a graded aggregate mixture on a base such as the ordinary gravel road. The softer materials will stand more distortion due to frost heaves, etc., without breaking up.

Our work in 1934 involved the use of 70-80 per cent oil, medium curing cut-back asphalt MC-2 and a grade of oil meeting the Asphalt Institute specification SC-3. The SC-3 oil has a higher viscosity than ordinary 70-80 per cent material and the mixture is more easily compacted.

The relative merits of slow curing asphaltic oil and medium curing cut-back as a binder for graded aggre-

gate, may be considered on the following basis: The surface mix with the former is quite flexible and for that reason will stand the ordinary frost heaves quite well without breaking up. It is easy to patch and the whole surface can be smoothed up or re-mixed when necessary. It has the disadvantage of being damaged more or less by tractor lugs, etc. When medium curing cut-back is used instead of slow curing oil, the surface becomes considerably harder and probably could not be re-mixed. It wears well, however, and when laid on a well drained base will give excellent service.

Our construction cost on oil-mix has averaged $1,61? per mile for 20 ft. width and 3 in. loose depth, or 13¾ ct. per square yard. Our average cost in 1934 was $1,530 per mile.

Comments and Recommendations.—The following comments and recommendations are based on the writer's experience.

Preparation of the existing roadbed should start some time in advance of the surfacing work.

The drainage should be checked and poorly drained areas tiled if necessary. The gutters should be cleaned out and the roadbed shaped up generally. A good time to make an inspection of the road is when the frost is leaving the ground. Frost boil areas can then be marked and later corrected by excavating and filling in with gravel or stone.

The minimum depth of metal necessary as a foundation will depend on the amount and kind of traffic and on the general character and drainage of the sub-grade. In general, a depth of at least 4 in. is desirable, but is not always necessary if the sub-grade is of a sandy or gravelly nature or is well-drained. If a road has stood up well in the past, it will make a satisfactory base, but it should be remembered that no bituminous surface is a substitute for a well drained roadbed.

In selecting a source of bank-run gravel for oil-mix, the following points should be kept in mind.

The material should be fairly clean and free from any clay coating. Lumps of cemented gravel or clay are objectionable. There should be a good gradation of the material from one inch down to fine sand. In loading the material, the full height of the bank should be worked at all times in order to eliminate the segregation, which is characteristic of the natural deposit.

Visual inspection is an aid in determining the suitability of the aggregate, but this should be checked by a sieve analysis.

Gravel conforming to the following requirements for grading is satisfactory:

Medium Cured Cut-Back Surface in Village of Fowlerville, Livingston County, Michigan

SC-3 Asphaltic Oil and Aggregate in Windrow While Being Mixed With Power Graders

Passing 1-in. screen—100%
Passing ¼-in. screen—60-80%
Passing 10-mesh sieve—35-60%
Passing 40-mesh sieve—20-40%
Passing 100-mesh sieve—8-15%
Passing 200-mesh sieve—5-10%

The weight of gravel aggregate conforming to these specifications is in the neighborhood of 110 lb. per cubic foot.

It is practically impossible to find bank-run gravel which contains sufficient fines to make the best oil-mix road. The dust in the salvaged road metal helps some, but there is not enough of it, so more must be added. The fine material should be mineral matter such as fine sand or stone dust rather than silt or clay.

Before placing new aggregate on the road, the surface should be well bladed with a heavy grader to remove all corrugations and provide a smooth hard surface.

All loose material should be scraped into a windrow and enough new material added to make up the required amount for the width and depth of surface under construction.

Device for Measuring Aggregate in Windrow.—In 1931, the writer designed a measuring device for the purpose of accurately measuring the aggregate in a windrow as it is placed on the road. It consists essentially of a rectangular box, or hopper, into which the gravel is dumped from the trucks. As it is pulled forward by the truck, an adjustable opening in the rear lets out the exact quantity of material required for the job and leaves it in a uniform flat topped windrow 6 ft. wide. The salvaged material is measured along with the new aggregate and the total volume of material is under definite control. By determining the weight per cubic foot of aggregate, the percentage of oil in the mix can be controlled within narrow limits.

The filler material may be placed on top of the measured windrows and will mix in without any appreciable change in tota! volume of aggregate and the added weight is easily determined.

If a prime coat is to be used, a good time to apply it is after shaping up the old roadbed and before placing any new aggregate on the road. The salvaged material may be scraped to one side while the priming material is being applied. One-fourth to one-third gallon of 50-60 per cent oil makes a satisfactory prime.

The moisture content of the aggregate should be considerably less than 2 per cent before application of oil. Investigation by the U. S. Bureau of Public Roads has

shown that a moisture content of 2 per cent or more in the mixture will seriously affect the stability of the surface. Therefore, the aggregate should be thoroughly disced and harrowed for at least a day before the oil is applied, in order to dry it out as much as possible. Having a dry aggregate will also speed up the mixing operation.

Determining Proper Percentage of Oil.—A number of formulas have been developed for determining the proper percentage of oil to use in the mix. Most of these formulas are based on the surface area which in turn is governed by the gradation of the aggregate. We have been using from 0.50 to 0.52 gal. per square yard per inch of loose material. This checks quite closely with the Stanton formula when the aggregate contains from 8 to 10 per cent material passing the 200-mesh sieve.

The Stanton formula is as follows:

$P = 0.02\ a$ plus $0.045\ b$ plus $0.18\ c$

Where P = percentage of oil in mix by weight

a = percentage of aggregate retained on No. 10 sieve

b = percentage of aggregate passing No. 10 and retained on No. 200 sieve

c = percentage of aggregate passing No. 200 sieve

The percentage of oil computed by use of the above formula runs a little over 5 per cent for the average well graded aggregate.

Use of too much oil and lack of fines in the aggregate are perhaps the cause of more trouble in connection with oil-mix roads than any other factor. Any oil-mix mat is bound to absorb more or less moisture from the subgrade and this moisture has the same effect on the stability of the mixture as so much additional oil. If the aggregate contains insufficient fine material, its bitumen capacity is low and the absorption of moisture will result in a very unstable mix. It is much easier to put the right percentage of oil in a properly graded aggregate during the construction of the job than it is to try to rectify the errors later on.

Before application of oil, the aggregate should be spread to a uniform depth and the width of the surface under construction. The oil should be applied in increments of not more than ½ gal. per square yard. The distance covered by each load should be checked and marked by setting a stake at the point where the distributor "blows." With proper care and skill in the operation of the distributor, the distance covered should be within 50 ft. of the computed distance. The material should be thoroughly disced immediately following each application of oil. After the oil has all been applied, the mixing is continued by blade graders or multiple blade mixers.

We have used power graders on most of our work. Care should be taken to see that the blades cut down to, but not into, the base during the mixing operation. If this is not watched, a mat of partially mixed material will be built up on the base and the result will be an uneven distribution of oil through the thickness of the mat.

The amount of mixing required will depend on the amount of moisture in the aggregate and the temperature of the air. In general, the mixing is about 70 per cent completed when the mixture is of a uniform color and contains so uncoated particles. Further mixing will cause the material to approach a jet black color and it will become less oily in appearance.

Before final spreading, a thickened edge should be provided for by making a triangular cut with a grader. This cut should be about 2 in. deep, tapering to nothing about 2 ft. in from the edge.

After the mixture is spread, it may be rolled, but we prefer not to do it until traffic has used the road for a few days. During this time, it is bladed daily and finally rolled and the result is a very easy riding surface.

Maintenance of Oil-Mix Surfaces.—The maintenance of oil-mix surfaces is not difficult, but it is important that repairs be made promptly where needed. Any small holes which develop should be filled at once with some of the mixture that was stock piled during construction. Small areas which fail, due to weak spots in the base, should be corrected by excavating to a depth of about 6 in. and filling in with oil gravel mixture thoroughly tamped. Larger areas may be strengthened by simply building up the thickness with oil-gravel mixture. Areas which corrugate, due to excessive moisture, may be repaired by scarifying and letting the moisture in the mixture evaporate.

Application of a seal coat is not always necessary, but is sometimes desirable from the standpoint of visibility at night and to provide better traction on hills and curves. Most of our roads have not been sealed. During the past summer, we sealed about four miles of road, using 0.2 gal. of asphalt emulsion covered with 12 lb. of birds-eye gravel per square yard.

This light seal served the purpose very well and the cost of materials is only about $250 per mile.

We have remixed about four miles of road, adding about ¼ gal. of oil per square yard. The cost of this work, including the oil was about $300 per mile.

Our annual maintenance cost on oil-mix roads have averaged $74.48 per mile, including what seal coat work we have done. The surface maintenance exclusive of seal coat has averaged $37.36 per mile for labor and materials.

We think we are conservative in estimating that the saving in maintenance cost will pay for the oil-mix surface in five years.

The foregoing is a paper presented at the recent Highway Conference at the University of Michigan.

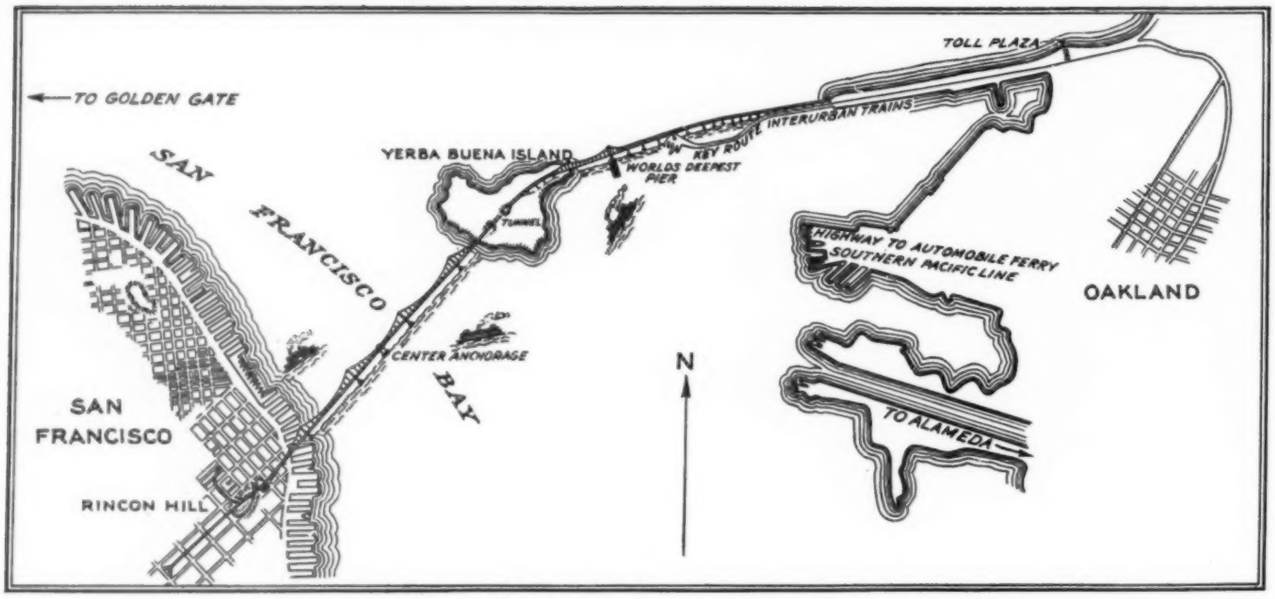
State Highway Work in Minnesota

Work of the state highway department of Minnesota in 1933 and 1934, as outlined in its biennial report issued early last month, includes the following:

Grading, 529 miles; graveling, 742 miles; bituminous surfacing, 451 miles; paving 154 miles; paving base, 127 miles; shouldering, 148 miles; new bridges, 54; bridges widened, 39; bridges rebuilt or repaired, 633; grade crossings eliminated, 27; dangerous center piers eliminated in underpasses, 13. In 1935, the report says, it is hoped to eliminate all remaining center piers on the trunk system.

Official mileage of the system, by types, is shown as follows: Total system, 11,339 miles, which is made up of 2,686 miles of concrete paving, 101 miles of bituminous pavement, 3,086 miles of bituminous treated gravel, 4,520 miles of untreated gravel, 74 miles of graded dirt road and 872 miles of ungraded dirt road. A considerable portion of the graveled roads, the report states, hardly comes up to that classification because the graveling is so light and is on inferior grades or foundations. Much of this type of road was added to the system in the 1934 expansion.

Owing to federal regulations governing most of the highway construction of the past biennium, the work was broken up into many small projects widely scattered over the state. This was done as an employment measure and resulted in providing more jobs, says the report, but it also increased the cost of the work.



General Map of San Francisco Bay Bridge

SAN FRANCISCO BAY BRIDGE

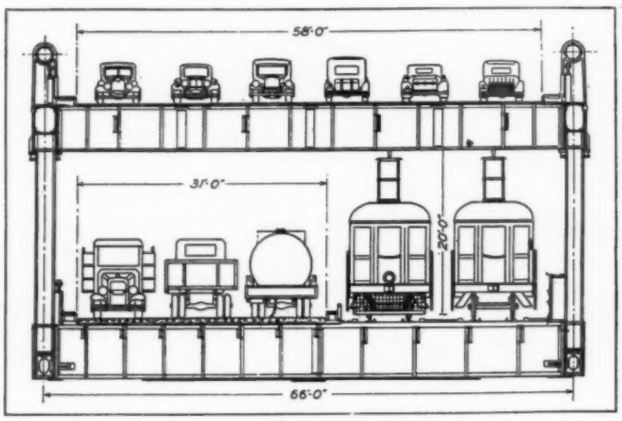
Present Status of Work—Traffic and Terminal Considerations—Some Interesting Construction Features

SPINNING was started in March on the first cable of the world's greatest bridge, and residents of San Francisco and its neighbor cities across the bay can now feel that construction of their seventy-years-cherished project has entered its final stage. Within two years the structure should be in service carrying more than 100,000 passengers daily.

B. Each main cable of the suspension system will contain 17,464 parallel wires spun by two 5 foot wheels operated at a speed of 600 ft. per minute on an endless cable extending between anchorages and over tower tops. Finished cable diameters will be 28¾ in. The wires are approximately 1/5 inch in diameter, and have a tensile strength of 235,000 pounds per square inch. The first cable to be constructed is from the Rincon Hill anchorage in San Francisco to the center anchorage half way to the island.

Progress on the long east side stretch is ahead of that on the west. As shown in the aerial view, the fourteen 288 foot spans and the first of the five 500 foot spans are in place; work is well along on the 1400 foot cantilever span, and it is expected that this major unit will be finished during the present year except for the 576 foot suspended truss between cantilever ends. On the island the 540 foot tunnel of record breaking cross section (76 ft. wide by 58 ft. high in the rough—65½ ft. by 53 ft. lined) and the trusses over lower ground are partly completed.

Traffic and Terminal Provisions.—Some 50,000 people and many automobiles make the round trip daily by ferry between the Oakland side and San Francisco. How far the new bridge will increase this traffic none can tell, but it is designed to carry in excess of 150,000 passengers by train and 75,000 by automobile. In computing prospective toll revenue the bridge planners estimated a traffic only slightly in excess of that which now crosses the bay daily, apparently feeling that financing should be on an ultra-conservative basis. Revenues so estimated will be sufficient to retire the bonds in 20 years; but beyond reasonable doubt the traffic will increase rapidly, and bonds can be retired earlier if desired. A similar conservatism on the part of some of our late boom



Cross Section Showing Traffic Lanes

promoters would have saved much grief in the past five years.

Eleven lines of traffic, grouped in three classes, are provided for. On the upper deck is a 58 ft. roadway with six lanes for high speed autos; while on the lower, three lines of heavy trucks are accommodated on a 31 ft. roadway, and two electric interurban railway tracks in the remaining space.

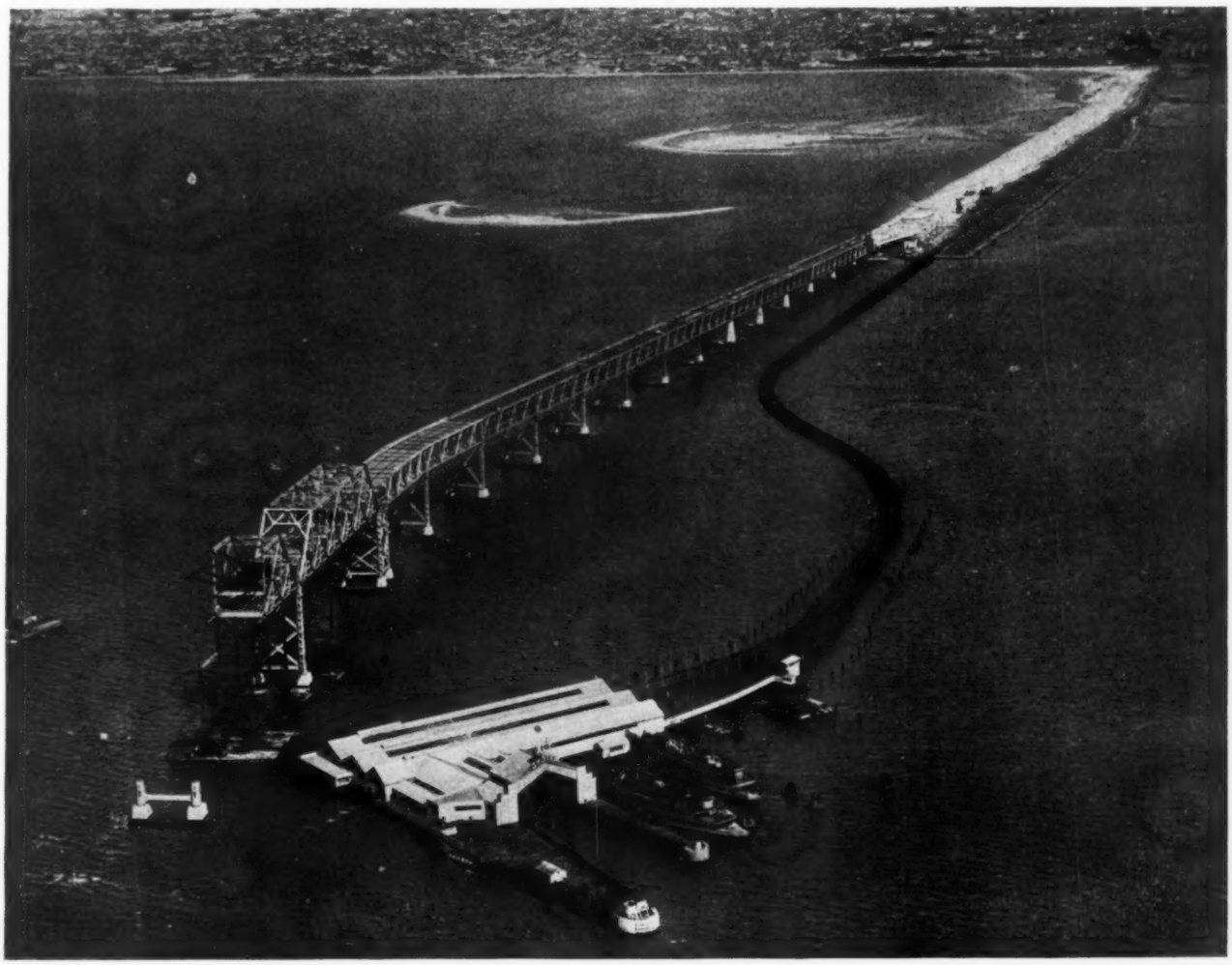
The San Francisco terminal presented special problems. Foundation conditions made it desirable, if not absolutely necessary, to bring the bridge into the city at a point some distance south of Market St.—the backbone of the city's street system—and much objection was raised to such a plan. However, the southerly location gave a direct connection with the traffic center of the city and afforded a much more suitable space for the necessary ramp approaches. These, and other considerations, including the fact that San Francisco's future growth must be to the south, ultimately led to its selection. A ramp will lead from the upper deck at this terminal to a point near the shopping and theater center, and side ramps will connect with the heavy business district. A single ramp will connect the lower deck with the industrial area.

On the Oakland side the terminal problem is simpler. Automobile traffic is all brought to a single level on an earth fill, and is then distributed three separate ways to the north, south, and east. The arrangement of elevated and surface roadways is such that it will be unnecessary for any car to cross a line of traffic.

An aid in the determination of terminal locations for each end of the bridge was a traffic census taken on the ferries. Total ferry traffic was known but the origins and destinations of that traffic were in large measure obscure until a record was compiled from cards filled out by passengers. This record made it possible to determine the centers, or points, at which traffic could converge and diverge with a minimum of confusion and inconvenience.

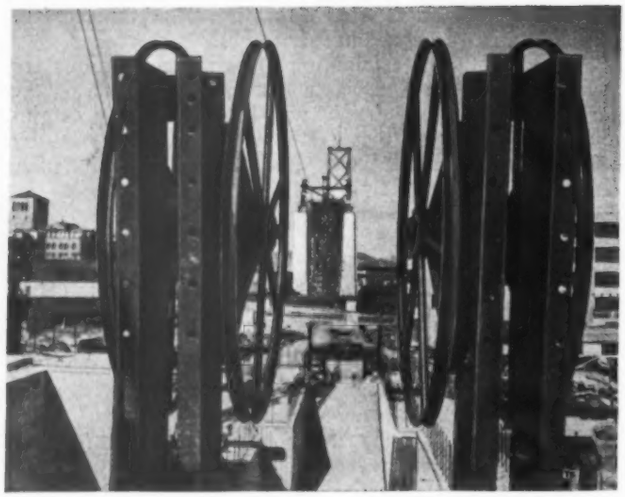
A Few Interesting Items.—Each main suspension span is 2,310 ft. long—a distance exceeded only by the George Washington bridge and the neighboring Golden Gate project. The main cantilever span, with its 1,400 ft. between tower center lines, is also among the aristocrats. The Firth of Forth bridge in Scotland, and the Quebec bridge on this continent are longer, but these three hold the records for cantilevers.

The eastern pier of the San Francisco Bay cantilever is founded on a hard deposit of sand, gravel, and clay 242 ft. below water level—the deepest pier foundation in the world. This pier, and two others supported on like material, are of cellular design, giving minimum foundation loads; piers for the suspension bridge towers are founded on solid rock from 100 to 240 ft. below water level. The three deeper ones are cellular, the fourth solid. The end towers have a height of 478 ft.



Wide World Photo

The Easterly Portion of San Francisco Bay Bridge. Aerial view taken March 28, 1935, showing the fourteen 288 foot deck spans and Span E-8, the first of the five 500 foot through spans erected, and traveller derrick erecting E-7, the second 500 foot span. Key Route ferry terminal in foreground



Wide World Photo

At the San Francisco End, March 22, 1935. Two wheels to be used in spinning the main cables from Rincon Hill anchorage to the center anchorage half way to Yerba Buena Island

above water, while the two middle towers reach 522 ft. This provides clearances of 227 ft. above water at the central part of the structure and 180 ft. at the shore.

The most unusual and interesting feature of the entire project is the "center anchorage" connecting the tandem suspension bridges. Its function is to prevent the large distortions which would occur under live loads, were a single unanchored span used between the central towers. This anchorage rests on solid rock at a depth of 222.4 ft. below water level. It is 197 ft. long and 92 ft. wide at the base, and of cellular construction.

The bridge cables entering it from opposite sides will be connected by triangular frames through which they will pull against each other. When live loads produce unequal cable pulls, the difference will be transmitted by the frames to the anchorage, and distortion prevented. The total height of the anchorage is nearly 300 ft. above water.

Excavation of the Yerba Buena tunnel will be by blasting and steam shovel following the cutting through of horseshoe-shaped periphery.

Throughout its entire length the project has been designed to resist earthquakes of greater intensity than have ever been recorded in California.

Great care has been exercised to give all features an attractive architectural character.

It is estimated that the cost of the bridge structure between approaches will be somewhat under $62,000,000. Several millions more will be necessary for approaches and for terminals, detail plans of which are not yet complete.

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Heavy Industries to Benefit from Road Building Program

Benefit to the heavy industries through the purchase of a large amount of road building machinery and equipment by highway contractors was forecast on April 8 by Irvin F. Lehman, President of the Blaw-Knox Co., Pittsburgh, Pa. The company is one of the largest independent fabricators of steel specialties, which includes an extended line of machinery and equipment for construction, street and road building purposes.

From information received from Charles Upham, Engineer-Director of American Road Builders' Association, the expenditure of $774,000,000 of federal and state money over a period of three years provided by the Hayden-Cartwright Act and the additional appropriation of $500,000,000 for highway and street construction, and $300,000,000 for grade-crossing elimination under the Work Relief Act of 1935 gives contractors assurance, for the first time in years, of a continuation of highway work which will justify them in making extensive purchases of new machinery and equipment.

"Highway and street contractors are now finishing up work under the federal appropriations of 1933 and 1934 with equipment which is largely worn out or depreciated, because of the large decline in the purchase of new road-building machinery and equipment since the end of 1931," he stated.

"Projects under the Public Works Bill of 1933, providing $400,000,000 for roads, and the Hayden-Cartwright Act of 1934 amounting to $320,000,000 of federal funds had been completed by the end of 1934, according to the Bureau of Public Roads, and the additional federal road work under construction on other projects totaled $147,809,000. In addition to this federal money there was approximately $200,000,000 of state money available for construction during 1934. The total amount of federal and state construction during 1934 was around $500,000,000. As of today there is yet available under the Hayden-Cartwright grant, about $62,000,000. In June 1935 $125,000,000 of federal aid will be available, and this must be matched by the states. A year later there is another $125,000,000 of federal aid available, to be matched by the states, and the Hayden amendment to the Relief Act provides $500,000,000 for roads and $300,000,000 for grade-crossing elimination. This, together with at least $100,000,000 of state funds for the next two years will total nearly $1,500,000,000 which will be available for the highway program during this period," he continued.

"The availability of these funds, coupled with the increased efficiency of federal and state agencies, the increased productive capacity of contractors, and the adaptability of the highway program in overcoming the unemployment problem, indicates that the total highway construction will run to more than $750,000,000 in the fiscal year beginning June 1st next," he added.

"This volume of work would require under present conditions the use of at least $125,000,000 of machinery and equipment, based on estimates of engineers that the total value of equipment used in many instances approaches 16 per cent of the year's business. The last census showed that highway contractors had approximately $85,000,000 of equipment and machinery at the end of 1929, of which more than $24,000,000 was bought during that year. There are no later figures, but it is certain that this inventory is appreciably reduced, for the annual depreciation on an average is estimated at 20 per cent and subsequent purchases have not been nearly that high. I calculate that the work represented by the $800,000,000 Public Works and the remaining $662,000,000 under the Hayden-Cartwright and state appropriations will stimulate the purchase of new machinery and equipment which has up until now been deferred," Mr. Lehman concluded.

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New York Increases Gas Tax—The additional tax of 1 cent a gallon on gasoline in New York State will be effective on April 1, 1935. It is expected that the retail price of gasoline will be raised throughout the state to absorb the new tax. This will make the service station price in Manhattan 15.5 cent a gallon, including taxes. The increased levy will bring the tax on gasoline by New York State to 4 cents a gallon.

.17 INCHES PER FOOT
.34
.67
LEFT SIDE OF STABILIZED ROAD HAS AVERAGE CROWN OF .42 INCHES PER FOOT AND IS IN GOOD CONDITION. RIGHT SIDE HAS AN AVERAGE CROWN OF .17 INCHES PER FOOT AND IS IN POOR CONDITION. (92)

Adequate Crown Prevents Puddling of Surface Water and Consequent Erosion

PROGRESS IN ROAD STABILIZATION
By the Use of Calcium Chloride

By FRED BURGGRAF

Research Engineer,
Calcium Chloride Association

THIS type of stabilization depends upon the properly proportioned quantities of the different sized aggregates, the quality of the binder-soil, the degree of compaction of the mixture and the maintaining of moisture bond by the use of calcium chloride.

During 1934 there was considerable progress made in this type of stabilization.

Progress in Specifications and Design.—The major changes in specifications and design were:

(1) The change in gradation sizes, by increasing the amount of coarse aggregate and decreasing the amount of soil mortar. The new gradation requirements permit 40 to 70 per cent of coarse aggregate or material coarser than the No. 10 mesh sieve. This change was made to increase wet weather stability.

(2) Another of the principal changes was the specifying of the integral use of calcium chloride instead of only a surface use as formerly recommended. By mixing the calcium chloride in the mixture at the rate of 0.5 lb. per square yard per inch depth, the compaction of the stabilized wearing course is greatly accelerated and the subsequent moisture content of the mat is regulated. There is also a decrease in loss of calcium chloride by run-off water, which prevailed under the old specifications.

(3) The organic content limitation on the clay was discontinued and instead of liquid limit requirement not to exceed 35 per cent was placed on the soil-fine fraction of the finished road. This not only eliminates the organic clays but also the detrimental micaceous types.

Progress in Construction.—Due to the general inexperience in the construction of this type of road, practically all of the earlier projects were built by force-account or maintenance crews. But during the past year this type has entered the contract field and at least six states have adopted specifications suitable for contract work and more than 100 miles have been awarded.

The usual method of combining the binder-soil with the other aggregate is accomplished by blading the materials back and forth across the road. But during 1934 a portable mixing plant was used on several projects and gave very satisfactory results. The manufacturer of this equipment has developed during the last few months a new portable-mixer that is lighter and less expensive than the type formerly used.

The manufacturers of commercial aggregates have also shown considerable interest in the possibilities of producing stabilized mixtures. This would utilize some of what are now waste fines at many plants and would reduce the mixing operations on the road.

During the past year there has been marked development in the methods for compacting the stabilized road mixture. Moisture is necessary to obtain compaction and the moisture content necessary to give the greatest density to which a stabilized mixture may be compacted by a specific method is the most important factor in obtaining a suitable road. It has been found that the usual type roller does not give as good results as that accomplished by controlled truck traffic or by a truck-tire roller. This is probably due to the combined effect of the "kneading" action which rearranges the graded aggregates into a denser mass under the influence of the greater unit pressure exerted by the smaller area of contact of the truck-wheel type of roller. This assures a uniform and high degree of compaction, throughout the depth of the stabilized mat. Tests made this past year on stabilized roads after thorough compaction were found to weigh 150 lb. per cubic foot. These test results

Mixing With Disc and Spike Tooth Harrows in Tandem

were taken as the basis for the computation of an Association bulletin on "Quantities of Materials for Compacted Stabilized Roads" which will be available in the near future.

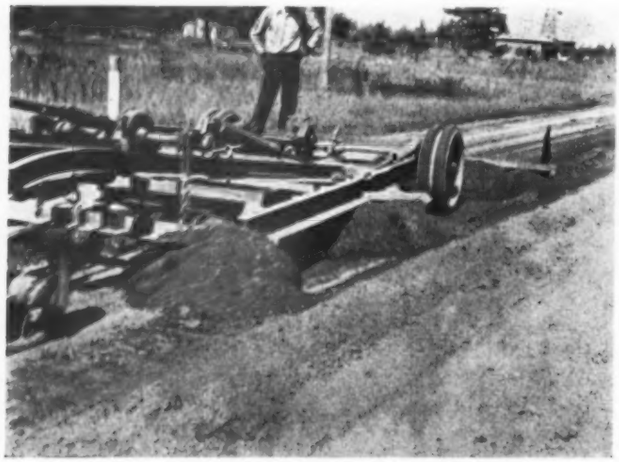
Probably the greatest development in the construction of these roads during the past year was the appreciation of the necessity of suitable crown. There is no need for excessive crown as a crown in the finished compacted road of .4 to .5 in. per foot is sufficient to cause the run-off of surface water and thus prevent pot-holing or other surface defects. A recent investigation confirms the need of suitable crown in stabilized roads. The case in point was an experimental stabilization project which had developed shallow pot-holing at intervals along the center of the road. Several reports were made on visual inspections, which attributed the condition to various inherent and external conditions, no one of which, of course, could be specifically proven.

However, when later examination involved soil analysis, determination density, and actual survey of crown and drainage conditions, of the affected and unaffected portions it was definitely shown that the trouble was correlated and attributable to the nature of the crown only.

The crown in the affected areas was less than .2 in. per foot.

In addition to the above mentioned developments, there were eighteen states in which calcium chloride stabilized road projects were constructed during 1934.

Progress in Maintenance Methods.—Experience has shown that a stabilized wearing course will require a method of upkeep differing from that for loosely bound surfaces.



Clay Pulverizing and Mixing Operations

Small holes or corrugations should be removed by blading only during and after rains which are sufficient to make the surface workable.

Advantages of blading when the road has been thoroughly wet are:

(a) Easier workability.

(b) Presence of sufficient moisture to permit consolidation of reshaped loose material under traffic.

Blading only after rains is usually sufficient to preserve smooth riding qualities, but in prolonged dry periods it is sometimes desirable to eliminate, by hand-patching, any scattered pits which may develop. A good mixture for such work consists of graded aggregate under ½ in. in size, mixed with at least an equal weight of stable sand-clay. Calcium chloride should be added to the patching mixture at the rate of 100 to 150 lb. per cubic yard, in order to provide moisture for rapid compaction.

The foregoing is an abstract of a paper presented at the annual meeting of the Highway Engineers' Association of Missouri.

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Luminous Traffic Signals

The International Commission on Illumination has a committee on traffic signals and a member of the staff of the National Bureau of Standards is the United States representative on this committee. According to the February Technical News Bulletin of the Bureau, for the purposes of the international committee an estimate has been made of the extent of use of luminous traffic signals in the United States, based upon statements of manufacturers as to their output. The estimates refer to Jan. 1, 1934.

Reports from manufacturers of signal glasses show the following output:

Green	116,700
Amber	88,400
Red	141,700
Total	346,800

The output of red glasses is 21 per cent higher than green, which can only be partly accounted for by the replacement of red for amber in the system of certain municipalities.

Reports from manufacturers of signal heads indicate that more than 29,000 intersections in the United States had been equipped. This is a lower limit, as the records are not complete.

Comparison of this figure with the output of signal glasses, without allowance for replacements, indicates an average of approximately 12 signal glasses per intersection. This is a reasonable ratio, as four 1-way 3-color signals would use exactly 12 glasses. A T-intersection using 2 colors would have only 6, while 4-way signals at each of 4 corners using 3 colors (as in Chicago) would involve 48 glasses.

Since the green glass is used in all systems, the number of sets of lenses may be based upon the green, which gives 4 sets of lenses per intersection, the exact number of 4 one-way signal heads.

The data received from manufacturers indicate that about 93 per cent of the installations use 3 colors and about 7 per cent use only 2 colors. The latter are largely in New York State and the Pacific coast cities. The output of amber glasses is, however, 24 per cent less than the green, which would indicate a much larger use of the two-color system.

HIGHWAY AND RAIL TRANSPORTATION IN TURKEY

By MAHMUT BAGDADI

A Turkish Student doing graduate work in Civil Engineering at Purdue University, 1934-35

I FEEL the necessity of giving you a very brief idea about Turkey, as to her political standing before the World War and after the revolutions against the Allies and the Sultan. By doing so, you can understand the transportation problem in Turkey much better. The conditions are not similar to the ones you have here. I shall try my best to show you the difference.

Before the World War, Turkey was known as the Ottoman Empire, whose boundaries extended from Bagdad to Greece. There were all sorts of peoples and nations mixed together; worst of all, the Arabs, who were never contented with the government. The Sultan had absolute power, therefore, the nation had to work for him and for his men, instead of he and his men being the servants of the people. Taxes were heavy, and all the money in the budget was used for the pleasure of the Sultan. Millions were spent to build palaces on the Bosphorous, and all public works were neglected. Transportation was by horseback because there were no roads for coaches to run over. Only within the towns the carriages could go. There were only a very few highways. The most important one extended about 1,000 miles from the Bosphorous, southeastward across Turkey. Most of this road was originally constructed by the Romans, and it was rebuilt by the Germans just before the World War.

The *only railroad* line existing in Turkey, was built by Germany. She had the concession for 100 years. This line was about 1,500 miles long. The intention of Germany was to connect Berlin with Bagdad by a long railroad. This was opposed by other European nations, especially England and France. This was one of the underlying causes of the World War.

Concessions and capitulations tied the hands of local industries, consequently, no factories were built. Everything was in the hands of foreign capitalists.

The Allies occupied Turkey after she had been defeated in the World War. She was divided among France, Italy, England, and Greece. America did not wish any share. These other nations afterwards were obliged to authorize Greece to stop the internal disorders in Anatolia. Greece received money, ammunition, and the other aids which were necessary for her to quiet the Turks. The Turks hated the Greeks because the Greek massacres, in April, 1919, in Smyrna, aroused general indignation in Turkey, which ended in the national determination to resist to the last, even if this meant total disintegration. The Turks did not want to accept the Greeks as their masters, thus the struggle for independence began.

Mustafa Kemal, an able soldier, began to organize an army against the Greeks. He succeeded, with the cooperation of the people. Men and women, old and young, all volunteered to help him stop the Greeks from massacreing the people. He succeeded in his plans. He was able to throw out the Greeks and the Allies from Turkey and forced them to sign a treaty in Lozan.

In 1923, the Sultan and his family were sent into exile and the same year, on the 29th day of October, the Turkish Republic was proclaimed. All the nations recognized the young republic. The first thing the government had to do was to stabilize itself. In order to achieve that, precautions had to be taken against attacks from outside, and probable civil wars. This could be done only by constructing highways and railroads in order to move troops rapidly to check the disorder or attack. Now we see that the purpose of building roads and railroads was not for public transportation. The object was to defend the country.

If we make a brief comparison of the highway problems of America with those of Turkey, we will see that in America the highways are built more for commercial purposes than for military purposes. One more item that I have to mention is that America is highly industrialized too. The more a nation is industrialized the more she needs the means of transportation. In Turkey the case is altogether different. She is not industrialized, therefore, the demand for transportation is not as great.

I mentioned that the Turkish Government had built roads and railroads with the sole idea of protecting the country. This was only a temporary precaution. When internal order was obtained a new problem arose and that was how to keep up so many thousand miles of railroad, how to check the competition of trucks. There was only one solution of the problem and that was to stop the maintenance and the construction of all roads that were parallel to railroads. Consequently, after a few years of negligence, it became impossible for the traffic to use these parallel roads, and the result was that the transportation began to pick up on the railroads. New highways were constructed running perpendicular to the railroads and the old roads leading to railroads were repaired.

The Turkish government still builds railroads and tries to have a net-work in the country. Since the proclamation of the republic she has built about 4,500 miles of railroad, and 16,000 miles of highways in ten years. The topography of Turkey being mountainous, it is very difficult and very expensive to carry on such construction. Much greater mileages might have been constructed with the same amount of money if the country were as level as America. I do not know the exact amount of money spent on highway and railroad projects in Turkey, but I am pretty sure that it was over $200,000,000. These plans were carried out mostly by Turkish contractors and some by Swiss firms. In all possible cases the use of local materials was obligatory.

Once construction of railroads was a matter of national defense, but now it is a matter of national economy. Turkey is one of those nations possessing rich, raw materials; rich mines, such as coal, copper, antimony, nickel, iron, etc., but none had been worked, therefore, it was up to the government to initiate enterprises to make use of natural resources. Building and operating railroads

NEW METHODS AND EQUIPMENT

On Illinois Highway Work

Photographs from C. M. Hathaway, Construction Engineer, Illinois Highway Department.

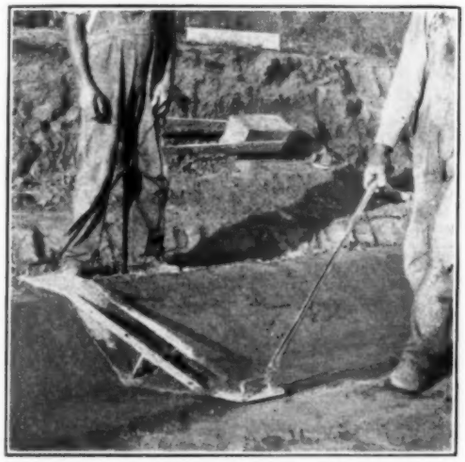
Stabilized Gravel Road from Chanderville East on S. A. Route 2 and 12, Cass County. Pulverized Clay and Gravel in Windrows on Each Side of Road Previous to Mixing.

Spreading Clay Over Gravel Preparatory to Mixing. O'Connor Construction Co., Springfield, Ill., Was the Contractor.

Dowel Bar Support Devised by Arcola Construction Co., Chicago, Ill., Commonly Used on Their Work.

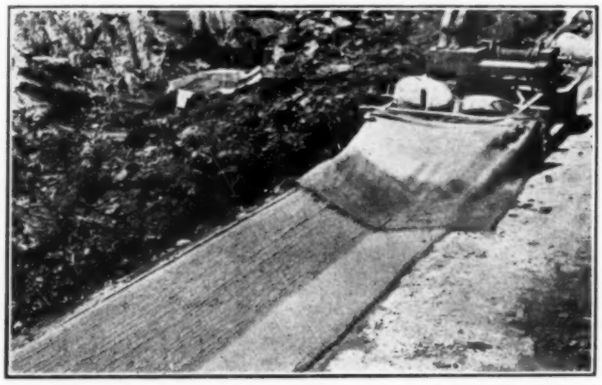
New Design of Sub-Grader on Job on Route 104. Cameron, Joyce & Co., Keokuk, Iowa, Contractors.

Special Sub-Grader Built for Gutter and Used by Edwardsville Construction Co., Edwardsville, Ill., on Route 150, Randolph County.



Steel Mule for Forming Gutter.

Gutter Construction on Route 150, Randolph County, Showing Special Finishing Drag to Which Is Attached Strip of Burlap.



Burlap Strip on Finishing Drag. This Equipment Gave Satisfactory Finish to Gutter. Edwardsville Construction Co., Edwardsville, Ill., Contractor.

would demand coal, hence consumption of coal will encourage the coal miners and in this way the coal mining industry developed. Mining was done to such an extent that a surplus of coal was produced, therefore, coal exportation began, which brings in annually about $30,000,000 to Turkey.

As I told you before, Turkey was not an industrial country, therefore, there was not much to transport by trains. It was necessary to find goods to transport besides the farming products. Therefore, the second step was to begin mining. Copper, lead, antimony, and iron mining began and developed rapidly. Exporting these resources developed another income for the national budget. It was necessary to use some of the iron, copper, antimony, and lead stocks, and that necessitated the construction of factories which tended to industrialize the nation. The aim was to create a self supporting nation from a people who had been the servants of the Sultans, and dependents of foreign capitalists.

With a view to help the farmers and to satisfy the transportation demand, 16,000 miles of highways were constructed. This is not much for a country like Turkey which has an area about 800,000 square miles and a present population of 14,000,000, but it is most impossible for one generation to do everything.

Well, now you may ask this question: Instead of constructing so many miles of railroads, whose first cost is maybe ten or twenty times as high as the first cost of a highway, why not construct ten or more times as much mileage of highways? Here comes the second point where Turkey differs totally from other nations, especially from America. The following points will show the difference:

1. Turkey has no automobile factories, therefore she has to buy from abroad.

2. Turkey has no oil fields, therefore she has to import all gasoline and oil that she needs.

These two items are sufficient to suck all the money from Turkey with almost no return. Since the major transportation could have been achieved by railroads, why not do it with them? Moreover, not only the first cost of construction is counted, but also the operating expense. Running cost of trains in Turkey is cheaper than the running expense of trucks, based on a unit amount of work done.

At the present time, the transportation over highways which are perpendicular to the railroads is largely by horse-drawn vehicles and only a small percentage by automobiles and trucks. Therefore, the types of roads needed for such traffic are:

1. Earth roads. The construction of these roads is very simple. Two parallel trenches about 20 ft. apart are opened. The earth from the trenches is thrown to the center and used as surfacing material. The crown is about 1 in. slope to 1 ft. They do not roll the surface. It is left to the traffic to compact it.

2. Broken stone macadam roads. Most of the roads are of this type.

The roads within the cities are mostly of stone or bituminous pavement. The roads that connect two close towns where there is no train service are mostly bituminous macadam pavements.

In conclusion, I may summarize the above as follows:

1. The highways in Turkey are practically all perpendicular to the railroad lines, in order to check the competition.

2. Most of the transportation is done by railroads.

3. The development of railroads, industrialized the country.

4. Railroad in Turkey is a means of national defense, as well as a national economy.

5. In the long run, transportation by train is safer and cheaper.

6. The highways are used mostly by horse-drawn vehicles, therefore, the kind of roads encountered are: earth road, broken stone macadam, and bituminous macadam roads.

7. Automobile transportation is not favorable because in Turkey there are neither automobile factories nor oil field. Therefore, if automobiles were used the national budget would have been decreased for no good reason.

Turkey has 22,000 miles of highways, 16,000 of which were constructed by the new Republic; and 7,000 miles of railway, 4,500 miles of which were built by the new Republic.

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Annual Meeting of A. R. B. A.

The regular annual meetings of the American Road Builders' Association will be held Thursday and Friday, April 25 and 26, 1935.

The regular annual meeting of the Association will be held Thursday, April 25th, at 10:30 a. m., at the offices of the Association, Suite 952 National Press Bldg., Washington, D. C. The officers and directors elected at the recent convention in Washington will be installed at this meeting. In addition, the reports of the Board of Directors and of the officers whose terms expire at this meeting will be presented, and such other business as may be deemed necessary will be transacted.

The annual meeting of the Highway Contractors' Division will be held Thursday afternoon, April 25th, at 3:00 o'clock, at the offices of the Association. Plans for the further extension and development of the Division will be outlined, and activities of national scope, dealing solely with the highway contractors' problems, will be considered.

On Friday morning, April 26th, at 10:30 o'clock, the regular annual meeting of the City Officials Division will be held at the offices of the Association. The newly-elected officers and directors of the Division will be installed at this meeting; the reports of the Board of Directors and of the officers whose terms expire at this meeting will be received; and such other business as may be found necessary will be transacted.

On Friday afternoon, April 26th, at 3:00 o'clock, there will also be held the regular annual meeting of the County Division, when the newly-elected officers and directors of the Division will be installed, and the reports of the Board of Directors and of the officers of the Division whose terms expire at this meeting will be presented; as well as any other business transacted which may be necessary.

In addition to the above, meetings will also be held of the Ways and Means Committee, the Planning Division and the Legislative Committee of the Association.

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TRANSPORTATION ECONOMIST AND COST ANALYST WANTED.—The U. S. Civil Service Commission, Washington, D. C., has announced open competitive examinations for the position of principal transportation economist and principal operating and cost analyst, Bureau of Statistics, Interstate Commerce Commission, Washington, D. C. Applications must be on file with the U. S. Civil Service Commission, Washington, D. C., not later than April 29, 1935. Entrance salary in each case is $5,600 per year.

ELECTRON-SHELLS, ELECTRON-ATMOSPHERES AND WEATHER

By HALBERT P. GILLETTE

UNTIL a wireless signal was sent across the Atlantic by Marconi, no physicist had dreamed that the earth is encased in one or more electron-shells. In fact Marconi's announcement of his achievement in 1901 was received with genial skepticism by physicists. Lord Rayleigh promptly remarked that wireless waves would be reflected from the earth's surface and therefore could not travel around the curved surface of the earth. But Marconi had accomplished what a "better informed" scientist like Rayleigh would never have attempted. Here is one of many instances where much learning is a dangerous thing, and a little learning is a blessing.

The history of science contains not a few similar instances. "Wise" astronomers never looked for a sun-spot cycle, but an "ignorant" German apothecary did—and after many years of observation found the now celebrated Schwabe sun-spot cycle. "Wise" geologists never dreamed of an Ice Age, but a biologist, ignorant of geology, did; and thus Agassiz revolutionized geology. "Wise" mathematicians never tried to improve on the old fashioned multiplication table, but a man very slightly trained in mathematics, undertook the task and succeeded. He was John Napier, inventor of logarithms. Incidentally his success furnished something beside evidence that it sometimes pays to be not too wise, I refer to the significant fact that he was sixty-four years old when "In 1614 appeared Napier's work which in the history of British science can be placed second only to Newton's Principia."

I could give, by the hour, similar successful instances of "fools rushing in where" so-called wise-men "feared to tread." There is a sort of "wisdom" that can see no hope for any new theory either if it conflicts in the least with any old theory or if it can not meet at once every objection raised against it. Curiously enough that type of "wisdom" is often found in men that are really wise and original, as exemplified in Lord Rayleigh.

Lord Rayleigh's scientific doubts were finally cleared away when Professors Kennelly and Heaviside independently suggested the existence of an ionsphere that would reflect radio waves back to the earth, and by a series of reflections or echoes enable such a wave to travel around the earth. Their suggestion was soon followed up by scientific observations that demonstrated the existence of "the Kennelly-Heaviside layer" at an elevation of about 62 miles; nor was it many years before another similar shell of ions was discovered by Appleton at a height of about 125 miles. Stoermer's radio echo observations indicate, I think the existence of several more terrestrial electron-shells of vast diameter.

I prefer to call these ionized layers electron-shells than to use the more common term ionsphere, for the evidence is very strong that they owe their properties mainly to electrons (negative charges) and not to protons (positive charges). The earth is constantly emitting electrons which would neutralize most of the protons in any ionsphere, leaving a great preponderance of electrons. The fact of a terrestrial emission of electrons has long been established, but it has been a puzzling fact. A common explanation has been that electrons emitted by the sun enter the earth near its magnetic poles, flowing in the well known spirals around magnetic lines of force. Then the electrons that thus enter near the poles are supposed to escape again in lower latitudes. This hypothesis is very plausible, but it only removes the puzzle from the earth to the sun. What causes a preponderance of electrons to escape from the sun? Dr. Swan has suggested that both in the earth and sun there is going on a destruction of more protons than electrons as a result of their mutual electric activity. This, too, is plausible. But it seems to me even more plausible that under great gravitative pressure both protons and electrons are being destroyed, and that the destruction of protons is greater than that of electrons. The less density of the electron would cause fewer electrons than protons to exist near the center of a heavenly body, and thus lead to disintegration of more protons than electrons.

Incidentally this hypothesis also explains why the luminosity of a star increases with its mass, which Swan's hypothesis does not explain. Whenever a scientific hypothesis explains phenomena that it was not originally designed to explain, the probability of its being true is increased.

The earth is emitting electrons, whatever the cause. Presumably other heavenly bodies are likewise emitting electrons. Therefore every planet and every star is probably the core of an atmosphere of electrons whose diameter is infinitely great. The mean density of such an electron-atmosphere must vary inversely as the square of the distance from the core. At intervals in such an electron-atmosphere there are probably rotating electron-shells, like the Kennelly-Heaviside shell and the Appleton shell. Since such electron-shells are rotating they are magnets, and their magnetic strength increases with the tangential velocity of rotation and with the number of electrons in the shell. This much is derivable from well known physical laws. We now come to an equally certain but surprising conclusion if there are such things as electron-atmospheres of vast diameter, namely, that:

The magnetic force of every electron-shell diminishes at a far less rate than does the force of gravitation, for it induces whirls of electrons in the electron-atmosphere.

In short the electron-atmospheres that permeate all space serve just as iron serves in concentrating magnetic lines of force. Let an iron filing be placed six inches away from the pole of a small bar magnet, and it will not move toward the magnet. But strew many iron filings between it and the magnet, and the lines of magnetic force will become so concentrated that the distant filing will be moved toward the magnet. In the case of the iron, certain of its arbital electrons become oriented by the magnetic force, and magnetism is said to be induced in the iron. Similarly magnetic polarity is induced in electron-atmospheres. The spiral path of moving electrons around magnetic lines of force is a well known laboratory phenomenon. The same thing must occur in electron-atmospheres.

It follows from this theory that if a terrestrial electron-shell gyrates, its axis points most directly sunward

at intervals, and when thus pointing it induces a maximum of magnetism in the vast electron-atmosphere that encases the sun. This results in pulling the terrestrial electron-shell sunward to a maximum extent. The resulting displacement of the shell, causes electron currents both in the earth's atmosphere and in the earth itself. Electrons moving in the atmosphere must cause air currents, and may, indeed, be responsible for much of the circulation now attributed to differences in temperature.

There has been a peculiar indifference among meteorologists as to any electric or magnetic theory of weather changes, in spite of the fact that the greatest of all electrical researches long ago advanced a magnetic theory of air currents. Perhaps this indifference is mainly due to not having read Faraday's theory, which briefly is as follows:

"It becomes a fair question of principle to inquire how far masses of air may be moved by the power of the magnetic force which pervades them. When two bulbs of oxygen in different states of density are subjected to a powerful magnet with an intense field of force, the mechanical displacement of one by the other is most striking. * * * And when so little as one-third of a cubic inch of oxygen can exert a force equal to the tenth of a grain, subject to the action of our powerful magnet, we may well conceive that the enormous sum of oxygen present in only a few miles of heated or cooled atmosphere, can compensate for the great difference of magnetic force, and so, by change of place, cause currents of winds having their origin in magnetic power."—Faraday's "Experimental Researches in Electricity," Vol. III, p. 265.

Faraday is here speaking of the effect of terrestrial magnetism upon oxygen, the most magnetic of gases, when it differs in density in different regions. The electron was not discovered until some 40 years after he advanced (in 1850) his magnetic theory of air currents We may be sure that he would not have been slow to see that air currents of much greater force can be caused by electrons in motion than by the action of terrestrial magnetism upon oxygen. The point that I am trying to make is that there is no well founded objection to a magnetic theory of weather changes when so great a researcher as Faraday espoused such a theory. I grant that existing physical theories have seemed to make it improbable that the Kennelly-Heaviside shell could be periodically displaced to any considerable extent either by its own magnetic action upon the sun or by the sun's magnetic action upon it. But let it be remembered that that very shell was not even suspected 35 years ago, and it will be admitted that hitherto unsuspected atmospheres of electrons may exist. If they exist, as above indicated, then the supposed impossibility of weather cycles due to magnetic action ceases to be an impossibility.

What is sorely needed is more of Faraday's optimism and less of the prevalent skepticism about magnetic force as a cause of air currents. Skepticism never has led to any important discovery, but it has often retarded the advance of science for generations.

Subsequent articles will discuss the reason why electron-shells exist, why terrestrial electron-shells gyrate and cause weather cycles, why cyclones and anticyclones are caused by terrestrial magnetic forces, why such whirls persist and travel, why the stratosphere is probably an electron-shell, how semi-diurnal barometric lows are caused by a distortion of electron-shells, why clouds often exist in distinct strata, and other phenomena that are well explained by the electron-shell theory.

Redecking Broadway Bridge In Camden, N. J.

THE overhead highway bridge No. 1.26X on line of Broadway, South Camden, N. J., adjacent to the plant of the New York Shipbuilding Co., crosses over the five tracks of the Pennsylvania-Reading Seashore Lines (originally the Atlantic City Railroad of the Reading Co.). It consists of a 120 ft. through riveted truss span (six panels at 20 ft.), with a center truss and two side trusses which carry two roadways, each approximately 17 ft. wide between curbs, and two sidewalks supported on cantilever floor-beam brackets. The bridge is square at the south end and has a 17 degree skew at the north end. The bridge was built in 1903, then rebuilt in 1918, and again in 1926 with wood plank decks. This deck consisted of steel plates on 4 in. planks, resting on 8 in. by 15 in. timber stringers spaced approximately 2 ft. centers, except under the trolley tracks (one in each lane) where 1-15 in. WF 74 lb. beam was used under each rail. All timber work was badly decayed.

The bridge is approached at both the north and the south ends by a 4 per cent tangent grade, and the traffic is not only very dense, but very heavy as well, for over 65 per cent consists of buses and heavy trucks.

The bridge acts as a main feeder to the important industrial towns and farming districts of South Jersey leading to the Delaware River Bridge and Camden-Philadelphia Ferries.

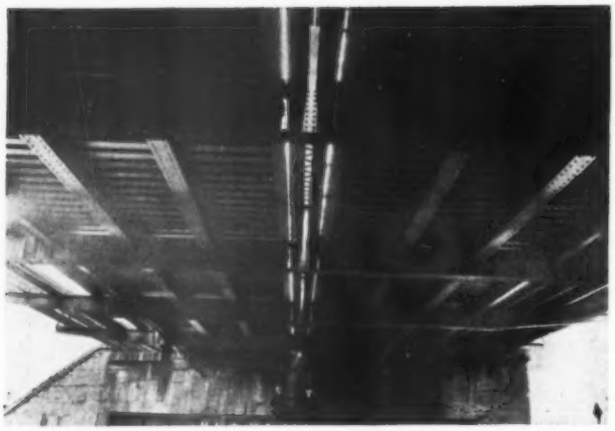
An accurate traffic count taken on December 5th (an average winter day) showed the following:

	Vehicles
8 a. m. to 4 p. m.	= 5,589
4 p. m. to 12 m.	= 2,518
12 m. to 8 a. m.	= 4,866
Total 24 hours	= 12,973

A traffic flow of 9 vehicles a minute, 540 an hour or 4,750,000 a year is heavy traffic for a two-lane bridge even in these times. Attention is called to the extremely heavy count between midnight and 8 a. m., due to the early morning trucking to the Philadelphia markets via the Delaware River Bridge and Ferries.

In replacing this deck, it was necessary to do one lane at a time, thereby diverting traffic over the other lane,

Interlocking Channel Floor in Place.



Underside of Bridge

and in doing so, owing to the narrow lane temporarily being used for the entire traffic, the Public Service Commission required 24 hour flagman duty at each end of the bridge on account of the approach grades and wide buses and trucks. This required six men daily for three 8-hour shifts to supervise the alternate two-way traffic.

As trolley service had been abandoned several years ago for bus service, the tracks were no longer required; therefore, the transit company removed same from one lane at a time as required by the construction program.

The general contractor then commenced work on the first lane by the removal of the traffic plates, plank floor and timber stringers, and re-framed and re-located the old steel trolley stringers to serve as future center roadway stringers. New steel outside stringers were then erected, making four lines for each lane spaced approximately 5½ ft. center to center. A new interlocking channel floor, made of heavy-weight 8 in. standard channels of copper bearing steel, was laid in mats the full roadway width and in sections 6 ft. wide, which required from 20 to 22 mats per lane. The mats were set by a standard truck crane which was also used to jack the floor mats down tightly on the stringers before any plug-welding was done.

The railroad company repaired the approaches at both ends. Both sidewalks were completely rebuilt of creosoted lumber, using 2 in. plank, by the master carpenter of the railroad company.

After the floor was in place, die-pressed asphalt filler planks were cemented in the troughs, and 1¼ in. mineral-surfaced asphalt plank was cemented to the alternate steel and asphalt surface with asphalt plank cement of the cut-back type.

As soon as the first lane was completed, traffic was immediately diverted over the new deck.

This procedure was then repeated for the second lane.

All the old steel diagonal bottom chord lateral bracing was burned off and removed, as the interlocking channel floor acts as the bracing system and leaves the underside of the deck in a clean condition.

The bridge has very close clearance over the railroad tracks, and after over 30 years of service, it was found that some of the bottom chord gusset plates on all three trusses were badly corroded below the floor line from the sulphurous gases which necessitated reinforcing them by arc welding flats.

All work was done under the direct supervision of the Pennsylvania-Reading Seashore Lines, A. R. Wilson, Engineer of Bridges and Buildings; Ralph S. Stewart, Division Engineer, and W. R. Ganser, Master Carpenter.

The general contractors were Brann & Stuart, Inc.

Belmont Iron Works furnished the "Belmont" interlocking channel floor, and the new steel required.

Benjamin Foster Co. furnished and laid the Johns-Manville asphalt plank.

Work was started on Nov. 13th and completed on Dec. 23, 1934, in time for the holiday traffic, in spite of severe cold weather and six days of rain.

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Budget Approved for Bituminous Road Materials Distributing Code Authority

The National Industrial Recovery Board has announced approval of a budget and basis of contribution for the bituminous road materials distributing industry code authority for the period Jan. 1 to Dec. 31, 1935.

The budget totals $62,900. Separate bases of contribution have been approved for firms applying liquid bituminous road materials and for firms engaged solely in the resale, processing or merchandising of materials not subject to the assessment for applied material. Approval of the contribution for resale, processing or merchandising firms was subject to suggestions or objections which have to be filed before March 27 with Deputy Administrator Beverly Ober, 4327 Department of Commerce Building, Washington.

The Board's order provides that previous contributions under approved budgets are to be credited to 1935 assessments. It also provides that until further order of the Board, the Code Authority may not expend funds for or incur expenses for the period after June 16, 1935, and that Code Authority expenditures until June 16 must be in ratio of the 167 days between Jan. 1 and June 16 to the 365 days covered by the full budget. No member of the industry shall be required before June 16 to pay more than 167/365 of his total assessment.

The basis of contribution for firms applying road material is fifteen one thousandths of one cent per gallon of liquid bituminous road materials applied by the use of mechanical distributing apparatus or by supply trucks, payable monthly for materials applied during the preceding month. An amount equal to $10 per piece of apparatus owned, operated, or leased for operation, or rented, is to be paid immediately, the payments to be credited to the total assessment.

The basis of contribution approved conditionally for resale, processing or merchandising of materials not subject to the other assessment is one-tenth of one per cent on sales for the previous month.

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Highway Tunnel Under Mont-Blanc Proposed.—A project has been presented to the French Government for the construction of a highway tunnel under Mont-Blanc which would connect France with Italy. It is planned to start conversations with Italy in order to obtain the Italian Government's agreement. The project plans the construction of the tunnel itself with two distinct galleries each 12 kilometers long (about 7.4 miles). It is estimated the work would cost 400,000,000 francs, which is proposed to be divided between France and Italy.

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A $10,000,000 Bridge for Scotland—A definite plan has been formulated for the construction of a bridge across the Tay in Scotland. The financial scheme of the Dundee Town Council provides for raising $10,000,000, the amount required for the bridge.

LONG SPAN BRIDGES

By CHARLES EVAN FOWLER

Consulting Engineer, New York City

THE truly long span bridges constructed during recent years represent a long stride forward from the days of the nineties, when the transition was in progress from iron to steel as the material from which to construct them. Then a 300-ft. fixed span was considered quite long, and the occasional design of a 400-ft. span was an event. When the three 550-ft. spans of the Huntington Bridge over the Ohio River at Cincinnati were built, it was a great event in engineering annals. There were it is true, some few really long spans, such as those of the Eads three arch spans over the Mississippi at St. Louis of over 500 ft. span, and which were made up of tubes said to be chromium steel, but which later analysis showed to contain little chromium. The Brooklyn suspension bridge of 1,595.5 ft. span, with cables of iron wire, was a truly long span. When the stiffening trusses of this bridge were half fabricated, it was discovered that the cost for this portion of the structure was going to be exceeded, so the sections of the other half were much reduced!

The writer's Knoxville cantilever was one of the first large bridges to be built entirely from steel, and the fact that it is still doing good service, shows the wisdom of the decision. The structure is 110 ft. high, with five main spans of equal length, two of which are anchor spans, and the five spans are flanked by two anchor arms. All the bottom chords are arcs of circles, so that the bridge has the appearance of five arched spans, thus making it a perfect example of engineering architecture, which has never been excelled.

When Lindenthal proposed a span of 2,750 ft. for his Hudson River design, it was a very bold step in advance, and when the Williamsburg suspension span at New York over the East River of 1,600 ft. span was built, that was considered a very long span for such heavy loading, although steel wire was used for the cables with a yield point of 145,000 lb. per square inch. The writer discovered in making erection plans for the approach spans and towers of this bridge, how great a factor the erection methods are in the cost of a long span bridge. Also how little the element of beauty was considered in making the design of such a structure. The great Forth Cantilever bridge in Scotland with its two spans of 1,710 ft., fell just short of having a beautiful outline.

The writer in 1912 prepared three designs for a Bay bridge at Goat Island in San Francisco harbor. The one with three 2,000 ft. cantilever spans from Goat Island to Telegraph Hill was carefully designed to have a pleasing outline, with elliptical curves for the bottom chords, and parabolic curves for the top chords. Then finials of proper height on the towers, added much to the pleasing appearance. The maximum size of the chords was 14 ft. double cellular octagonal section, which type was also employed in a design by the writer for the 1,650 ft. arch at Sydney, Australia, although the maximum chords were only 8 ft. in diameter. The second design for the San Francisco bridge had three 2,400 ft. suspension spans in place of the cantilevers. The third design was for three 2,350 ft. cantilever spans for the same portion of the bridge. The approach from Oakland to Goat Island was the same for all three plans, with a cantilever span back of Goat Island. One member of the writer's Board of Engineers proposed a layout, with the long spans extending from Goat Island to Rincon Hill instead of to Telegraph Hill, but careful study disclosed what a terrible mistake it would be to land such a great traffic to the left side of Market street, so that it would have to cross through the congested traffic of that great thoroughfare. For the suspension design it was found entirely unnecessary to have any anchorage midway, as a European system of self anchoring and very economical cables was embodied in the design, which also made it practically impossible for the cables to be shot down in war time. The writer's brochure "The San Francisco-Oakland Bridge" shows all three of these designs, which provided for railway tracks below, and roadways above, with approaches in San Francisco which would have prevented any congestion. The question of piers in the shipways was always a serious problem, and a fourth design was made by the writer for a 4,850 ft. suspension span between Goat Island and Telegraph Hill, which is illustrated in "The Ideals of Engineering Architecture." The location was peculiarly suited to such a structure, as there would be rock anchorages on both shores, and both side spans of 2,425 ft. each would be loaded. Such a long span of the suspension type is proportionately cheaper than for a shorter span due to the great inertia of such a great span. This is the bridge that should have been built instead of the three 2,400 ft. (2,310 ft. as used) suspension bridge, with an unnecessary anchorage in the middle.

When the first design or hybrid cantilever and suspension bridge was proposed for the Golden Gate, the late J. Bernard Walker, then editor of the Scientific American, asked the writer to write a discussion of the plan, as it did not appear logical to him. The substitute design proposed and illustrated alongside of the hybrid one, was for a 4,200 ft. simple suspension bridge, or possibly to be lengthened if borings showed it to be necessary. The trouble encountered in building the 4,200 ft. span, as finally adopted, proves that the span should have been longer.

When the problem of a bridge across the Narrows at New York, between Brooklyn and Staten Island, was submitted to the writer for solution, it was found necessary to provide a main span of 4,550 ft., as illustrated in "Engineering Architecture." With the side spans loaded, this made a suspended superstructure of 9,100 ft. in length, and having a clearance of 245 ft. above the water at the center. The problem of tower piers was somewhat of a serious one, although not proportionately so for a bridge with 18 traffic lanes, and to cost $60,000,000. The depth to rock was found to be about 200 ft. when borings were obtained, and a very special design of piers had to be made, although very different from that for San Francisco, where the writer's scheme was used by the builders, as was that for the bridge itself.

The only feasible design for a bridge over the Straits of Mackinac in Michigan was found to be by way of

the Islands, with the first 1½ mile section of 500 ft. cantilevers. The channel span at Mackinac Island is a 1,300 ft. clear span with 135 ft. clearance, of the arched cantilever type, with 600 ft. anchor arms. The last 2 mile section is of 900 ft. cantilevers, with 600 ft. anchor spans. Including the roadway over the Islands and the causeway fills, the total length of the project is 25 miles to cost $35,000,000 for a combined highway and railroad crossing. The layman would ask why the direct crossing of only 3½ miles was not adopted. But of course the depth of 220 to 285 ft. has to be considered, and the very serious problem of ice pack and ice fields of from 1½ to 2 miles across.

Very careful estimates showed that a cantilever design with two 1,500 ft. spans, an anchor span of 1,000 ft. span, and two 750 ft. anchor arms, flanked by cantilever approaches, would cost $54,000,000 for a 40 ft. wide highway bridge. There would be no assurance as to how long such a structure would withstand the ice packs and ice floes.

The only design that could be guaranteed as permanent would be a 5,280 ft. suspension span, with loaded side spans, or a total suspended structure of 10,560 ft. in length. There would be two roadways braced apart to a total width of 200 ft. The towers would be over 715 ft. above the water, and the anchorages 500 ft. in length for each one. The cost of $65,000,000 would make such a project impossible from any possible earnings in the near future.

The Detroit-Windsor bridge design was originally made by the writer to carry both highway and railway traffic, and was to have eight cables carrying heavy trusses and floor systems, comprising the heaviest bridge of the kind in the world. The back stays have a very flat angle, thus giving the structure as fine an architectural appearance as a suspension bridge with the back stays loaded. The outline was retained when the bridge was built for highway traffic, and when completed it was the longest span in existence. The Hudson River bridge at New York City with its 3,500 ft. span was soon completed to exceed the length of the Detroit bridge, but with its steep back stays, its architectural appearance was spoiled, and besides it has an appearance of instability. The Golden Gate bridge will soon take the palm as the world's longest span. The writer's investigations in making a design for a 1,500 ft. suspension bridge for an arm of San Francisco Bay, disclosed that the stiffening trusses as designed according to existing formulae are unnecessarily heavy, and that they may be lightened according to a curve that reaches zero at 5,000 ft. span. This was verified by the investigations made for the Detroit bridge, which confirmed that the increasing inertia as the span length increased, lessened the need for heavy stiffening trusses.

The theoretical methods which are used in determining the number of spans to be used for any given crossing to produce the most economical bridge, such as is given in the writer's Sub-Aqueous Foundations, can never be applied to the design of very large bridges. There are so many factors that must be considered in the design of large cantilevers, arches, and suspension bridges, that span lengths and other features of design must be decided without regard to the best economy. Thus for the Detroit bridge, the George Washington bridge, and the Narrow's crossing, the full channel must be spanned to satisfy navigation needs; while for a crossing of the Straits of Mackinac the ice conditions become the controlling factor. When the span lengths have been fixed, then and then only may economy be considered in the niceities of the design itself, the kind of materials to be used, and the method of erection. Such problems will call forth all the ability and experience of the designer, and will make the structure a real success or failure as an engineering and economical problem.

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High Lights of California Traffic Survey

The Division of Highways of the State Department of Public Works has recently completed an exhaustive traffic survey of the roads and streets of California made during the year 1934 which reveals that the total annual motor travel in the state is 16,600,000,000 vehicle miles, of which 47 per cent occurs on state highways, 11.5 on county roads and 41.5 on city streets other than state highways.

This survey represents a year's work and the employment of 14,000 checkers and statisticians in field and office, supervised by the Maintenance Department of the Division of Highways.

The survey was accomplished through financial aid from the Federal Civil Works Administration and the State Emergency Relief Administration. Some of high lights developed by the survey are summarized by C. H. Purcell, State Highway Engineer, in the March issue of California Highways and Public Roads from which the notes in this article are taken:

State highways outside of cities carry three-fourths of all traffic outside of cities. State highways inside cities carry one-fourth of all city traffic.

State highways within cities of California have 1/18 of the mileage within the cities and carry one-fourth of the traffic.

Of the total annual vehicle mileage in California, 55.6 per cent occurs within cities. The remaining 44.4 per cent of California's traffic flows outside of cities and three fourths of this rural traffic moves on roads of the State Highway System.

Expenditures Compared.—The aggregate expenditures for vehicle regulation and highways since 1914 and since 1929 are given for comparison as follows:

	1914-1933	Per cent
State	$384,000,000	30.4
Counties	467,000,000	36.9
Cities	414,000,000	32.7
	$1,265,000,000	100.0

	1929-1933	Per cent
State	$185,000,000	35.1
Counties	147,000,000	27.9
Cities	195,000,000	37.0
	$527,000,000	100.0

Vehicle regulation and highway expenditures per vehicle mile in 1933 by the three governmental units were as follows:

State	$0.0046
Counties	.0126
Cities	.0040
Average	.0053

Road and Street Mileage.—The total road and street mileage in California is 95,957 miles, of which 13,605 miles are state highways, 65,130 miles are county roads, and 17,222 miles are city streets other than those in the State Highway System.

The State Highway System has 8,984 miles of high and intermediate type of surfacing. The city system has 11,427 miles, and the counties, 11,116 miles.

Approximately one-third of all the road mileage in California is of high type or intermediate type surface, which classification embraces Portland cement concrete, asphaltic concrete, oil mix and oil macadam pavements.

PROGRESS IN ROADSIDE DEVELOPMENT

PRIOR to June 1933, when "The appropriate landscaping of parkways or roadsides on a reasonably extensive mileage" were emphasized in the Public Works high program, only a handful of states had seriously considered the possibilities of comprehensive roadside improvement. By the end of 1934, however, practically every state had work of this character underway or contemplated, including even the far-distant Territory of Hawaii. In the comparatively short period of one year, the state highway departments have programmed approximately 1,000 miles of roadside improvements, distributed in nearly 300 projects, averaging slightly more than 3.5 miles each in length. This accomplishment is gratifying inasmuch as many of the state highway departments, because of the pressure under which they were operating during the stress of the emergency program, did not really get organized for this relatively newer phase of highway activity until early in 1934. An interesting account of what is being done in this field was given by Wilbur H. Simonson, Senior Landscape Architect, U. S. Bureau of Public Roads, in a paper presented at the recent Purdue Road School, from which the notes in this article are taken. The amount of landscape work undertaken during the first year of operation under Section 204 of the Recovery Act is very encouraging. The estimated cost of the work on the approved projects in 42 states is $1,590,037, or an average estimated cost of approximately $1,600 per mile. The majority of the specially selected projects are located on main arteries of travel, generally adjacent to the corporate limits of the more important communities, where sufficient right of way is available to undertake satisfactory landscape work.

Cost Actual Planting and Seeding Operations.—Contrary to a somewhat general belief, the cost of comprehensive roadside improvement is not absorbed largely in the purchase and planting of trees and shrubs, for only about one-third of the estimated cost of the improvement is spent for the purchase of plants and seeds and the actual planting operations. On this basis, it may be assumed that approximately one-half million dollars has been or will be expended on the actual planting and seeding of the 275 projects already approved, for a total of considerably more than one (1,133,202) million plants, consisting of 116,262 trees, 538,147 shrubs, 478,793 vines, and a large number of acres of seeding and sodding. Roughly, this would approximate $500 per mile average cost for the actual planting and seeding operations, not including the requisite advance preparations or aftercare of the projects.

Landscape Organization.—The necessity for properly trained and experienced guidance cannot be overemphasized as the quality of the completed work depends upon the staff organization in charge of development work of this character.

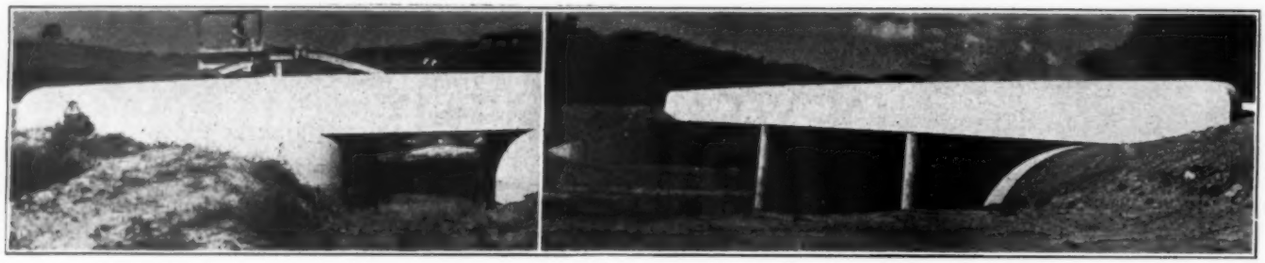
The majority of the state highway departments have found it advisable to employ landscape architects and landscape engineers to plan and direct their roadside improvement programs. Some idea of the character of the organizations that are being developed may be supplied by the kind of men that have been put in charge of the work; either in the design or plans and surveys division or in the maintenance and/or construction divisions of the department.

In 25 states they bear the title of landscape engineer, but there are technically trained landscape architects among the incumbents. In 6 states the roadside men are known as landscape foresters; in 4 they are landscape architects; 3 states employ arboriculturists; 2 depend upon state university specialists; 2 have delegated the job to their maintenance engineers; 2 have made it the function of assistant engineers with the advice of specialists; and one state highway department has the cooperation of the state park engineer—clearly a diversity of experimental supervision.

Basic Landscape Principles Important.—The attractive appearance of the surface features of a highway is dependent upon basic landscape principles. In practically all of these states notable progress has been made in placing this phase of highway work on a scientific footing. Especially encouraging is the evidence that the highway engineers are "landscape conscious" and are rapidly becoming familiar with the fundamental objectives of roadside development through collaboration with the landscape men in the preparation of plans and specifications.

One of the tendencies observed as a result of highway and landscape engineers jointly working together on this common development and design problem is that the highway engineer very soon appreciated the fact that landscape architectural considerations in the design and construction of a modern highway are just as important as any other considerations, and that it is fundamental that such considerations be developed with forethought as an integral part of the road construction and not added to it as an afterthought or "decorative dolling-up" after the road has been completed. The basic ideas should be developed, not in sequence, but simultaneously in the work of design and construction as a dual function of highway planning. The sound economy of such a practical cooperative approach appeals to the engineer who has had an understanding contact with this relatively new phase of highway development. Perhaps the indirect influence of such comprehensive demonstrations upon the basic principles governing highway development may be as effective in an intangible way as the direct value to the public of the tangible demonstrations.

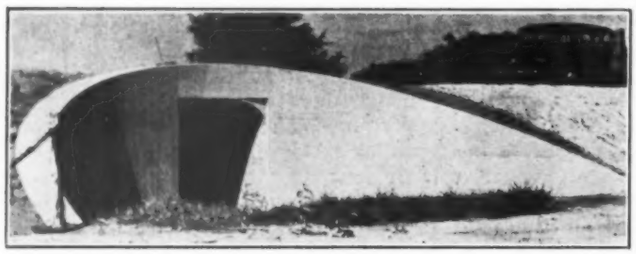
The Highway a Part of the Landscape.—The progressive improvement of our highway surfaces is paralleled by the progressively broadening concept of the highway as a traffic service unit that includes the sides of the road as an integral part along with the pavement design and construction. The present primary problem is to fit the highway and the details of construction into its natural surroundings through the preservation of the good features of its rural or urban character. Perhaps the chief need is wider right of ways to permit expansion and better curvatures and alignment. The safety factor is the major item in the design of highways, and for a maximum of safety, room is essential. In an effort to remove the raw appearance of new construction, state highway departments are giving more thoughtful consideration to the protection of the existing growth of trees and other native plants along the way. Standard cross-sections are modified so that the resulting cross-section will always be in harmony with the landscape. Earth slopes in cuts and fills are flattened and liberally rounded during grading operation to a more stable and natural appearance.



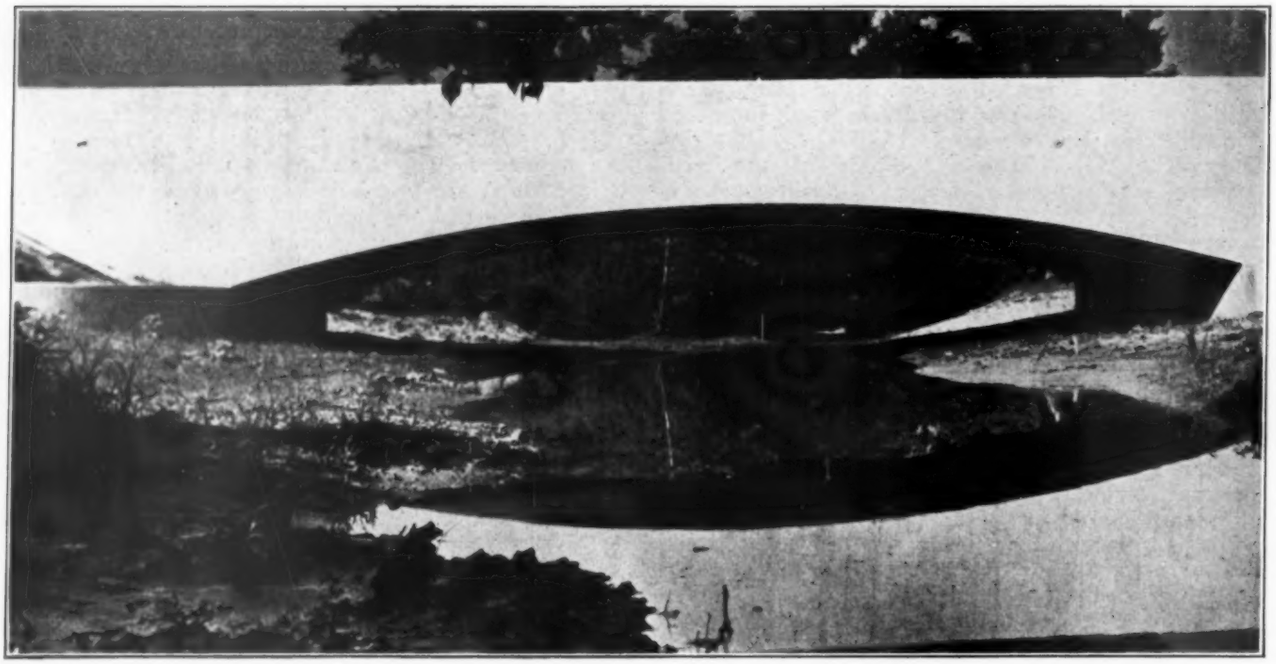
Some T.V. A. Designs for Small Concrete Bridges and Culverts

A contribution to small concrete bridge and culvert design has been made by engineers of TVA in 1934.

Architecture of monumental bridges is not new. Likewise, smaller bridge structures have received certain attention. The tendency, with such effort, has been by use of ornament.



A notable contribution of 1934 in design of small concrete bridges and culverts comes from engineers of the TVA, who gain beauty solely by use of plane surfaces, good proportions and graceful curves and arches. These designs are in step with the modern tendency toward simplicity and elimination of ornamentation which serves no useful purpose. It has the additional feature of economical construction cost to commend it, as form work is simplified and placing costs reduced. The accompanying illustrations show a number of types of structures, all built in accord with these principles. They have been the subject of much comment by visitors in the TVA.



Borrow is designed in the road plans and is not evident as such. Side ditches are being widened and made less hazardous, and more attention is being given to the pleasing appearance of necessary structures. The engineering leadership of the country appreciates the economic value of all these various factors of fundamental highway design as essential elements in the protection of the highway investment. The adoption of these forward looking policies in some of the states indicates the value of the collaboration of the highway engineer and the landscape architect from the inception of a project. It is vital that the landscape considerations be analyzed before a highway location is made rather than after plans and construction are started. Under this arrangement many pleasing landscape features may be worked into the design and construction at no additional cost.

It is realized that the natural scenic environment along highways is fast becoming one of the most valuable assets of national life. For this reason, the proper design of a highway includes the treatment and regulation of the roadsides as well as the roadway proper. The entire area of the right of way, including the regulation of the entire landscape visible from the highway and the preservation and restoration of the beauty of the natural landscape, should be considered as an integrated and completely unified road section, wherein slopes are flattened to reduce erosion, ditches are made less hazardous, native trees are saved, and a generally neat and clean appearance prevails. It is more economical to include these more permanent features in the initial construction than it is to attempt to do it as a separate operation after a highway is finished. Every effort of this nature is a direct contribution to the necessary preparation for the ultimate planting of a highway, and to that extent simplifies this final part of the work.

There are many places where comprehensive improvements can only follow appropriate legislation. As highway departments go on with improvement work of this character, there will be profit in experience, both as to personnel and as to the method of organization and of operation. Clearly, the improvement of the highway roadside is becoming a problem for intimate study.

Appearance of Roadside Structures.—Landscape design must be coupled with good engineering in order to obtain the best results. Architectural improvement of roadside structures along highways also forms a part of the whole problem. The distinctive beauties of the individual states or regions should be expressed in appropriate design and local materials to counteract the trend toward standardization. Well-designed gas stations, reflecting the craft and materials of the section would be much more suitable than some of the present attempts at all manner of picturesque buildings that show little taste or thought in their planning. The same considerations apply to the roadside tourist lodge and camp structures. There are existing examples of such structures that indicate how knowledge and feeling, rather than cost, determine quality and good taste in architecture.

Landscape Plantings.—Tree groups and ground covers, with some distinctly native wild materials, have proved to be most appropriate as an expression of fine natural development; the trees for skyline interest, and the ground cover types for erosion control, to allow for a reasonable amount of variety and landscape interest. Simplification in a well-conceived plan and neatness in cleanup after construction will go further to improve appearances than will most of the efforts toward landscape improvement. Simplicity of treatment is recommended as being economical to prepare and to maintain as well as generally more satisfactory esthetically. Good practice in roadside improvement aims to work with nature and to work with the citizens of the community. Highway harmony may be developed in this cooperative way at the lowest expense.

We are learning that varying conditions require varying treatment—that local adjustments to the various problems are desirable to obtain worthwhile results. More permanent and satisfactory results are assured where practical common-sense adjustments are made, in the planning and during construction, to fit the needs of each individual highway. The scars of construction have heretofore sprung from the standardized mechanical methods of the recent era of mass production of highway mileage. Fortunately, we are yet in a position to profit from the factory-method experiences of the drafting room, which may be avoided by giving considerable more attention to the varying conditions in the field. More field checking of detail plans would be desirable. Highway safety, utility and beauty is largely dependent upon the location alignment and grading. One of the best protections against the most frequent source of accidents is a good roadbed surfacing, with an ample width of shoulder, and with gentle easy slopes away from the shoulder. A highway is beautiful largely to the extent that it has the appearance of nature undisturbed.

"Never design what you cannot maintain" is a good thought in highway design. In estimating the economy of any contemplated roadside improvement, the question is, "How much can we afford to invest now to save a determined amount of annual maintenance expenditure?" It can be answered by comparing the additional investment with the saving in cost which it effects. And it is axiomatic that the principles of safety and good appearance are inseparable. Every scientific effort made by the highway engineer to improve traffic safety usually effects an equal or comparable improvement in the appearance of the highway. Steady and constant progress is being made in the development of the highway system of the United States so the roads may lose their look of newness and be harmonized with the landscape as if they had sprung from the soil.

The Public Works program has served to make a beginning in roadside improvement in each of the states and to create a popular demand for such improvements. A growing general interest in the comprehensive development of the modern highway is indicated. It is indicative of the need for constant collaboration between the several departments of the highway organization for the effective and proper solution of their common problems. One of the primary values of the demonstration projects included in the first year of activities of the Public Works highway program is largely in the opportunity it has presented to develop this requisite cooperation and to prove its results both to the highway builders and to the public. It is the confident expectation of Federal authorities that the results will be generally satisfactory and that what is now a national demonstration will very quickly become an accepted policy.

Work-Relief Value.—Highway building today should have the goal of creating employment, but an objective of equal importance should be the improvement of roads that will constitute an effective answer to the problem of traffic safety. It is of particular interest at the present time that approximately two-thirds of the roadside improvement expenditure goes directly to labor on the local job, while a large part of the remaining third goes to labor employed in growing and supplying plant material. Roadside development, being so largely handwork, affords unusual opportunities for state, counties, and cities, to distribute and spread work-relief to various classes of labor.

Cast Iron Road Surfacing Test at Wilmington, Del.

ADDITIONAL evidence of the continuing interest in cast-iron roadway surfacing is indicated by the installation of a 30 ft. test section in Wilmington, Del., by the State Highway Department, the City Street and Sewer Department, and the Lobdell Car Wheel Co. The test is being made to verify the many claims of the European engineers for the advantages of this type of roadway surfacing.

The first test of cast-iron roadway surfacing laid in the United States is believed to be that installed in October, 1934, on Fifteenth Ave. at Washington on the campus of the University of Minnesota in Minneapolis. The pavement is 24 ft. wide between concrete gutters and 30 ft. long. The cast-iron plates used in the Minneapolis test are triangular in shape of the type made by Iron Paving, Ltd., of London.

The test section just installed in Wilmington, Del., was laid in connection with the widening and re-surfacing of two city streets to serve as a by-pass for heavy truck traffic to relieve the congestion on the streets in the central portion of the city and is expected to afford an excellent opportunity to study the performance of this type of pavement under severe traffic conditions. It is located on Spruce St. about 30 ft. from the intersection with East Fourth St. The pavement is 28 ft. wide between concrete gutters and 30 ft. long. The plates used in this test are a departure from the conventional European designs and were designed by the Lobdell Car Wheel Co. in collaboration with W. W. Mack, Chief Engineer State Highway Department, and E. Earle Downing, Resident Engineer for New Castle County of the State Highway Department and Harry L. Maier, Chief Engineer of the Street and Sewer Department of Wilmington.

Desiring to eliminate the straight line joints which are characteristic of the European designs and to reduce vibration of traffic, the plates were made in the form of an irregular hexagon and the surface bosses or studs increased in area and so placed that their surfaces overlap thus giving a smoother surface to traffic and reducing the objectionable vibration.

Special header, corner and side plates were made of considerably greater area than the plates used in the main area of the pavement to afford security to the edges and prevent the tendency of starting of any loosening or failure due to inequalities between the cast-iron and adjoining pavement. The smaller hexagonal plates making up the main body of the pavement are approximately 10 in. wide and 20 in. long from apex to apex. They have small ¼ in. studs on the edges so placed to insure an opening between the plates of at least ¼ in. They are 9/16 in. thick with 2 in. square raised bosses 5/16 in. high arranged at 45 degrees with the center line and separated by about 1 in. The under surface is reinforced by ribs which make the effective depth of the plates from the top surface of the bosses to the bottom of the ribs 1½ in. The weight of these plates is about 32 lb. each. The weight of the finished pavement (the cast-iron only) is about 265 lb. per square yard.

Since the rather limited quantity required for this installation (18 headers, 4 corners, 22 sides and 682 main plates, 720 castings in all) did not warrant the investment in special moulding equipment that would be necessary for the most economical production, very little actual data could be obtained on the ultimate cost of production. The plates were actually produced at a cost of approximately $5.50 per square yard of effective area.

Owing to the fact that the test installation had to be laid to match with a 2 in. thick bithulitic concrete surfacing used on the remainder of the street, it was necessary to lay it upon a cushion approximately 1¼ in. thick. A loose cement and sand cushion (3 parts sand, 1 part cement slightly dampened) was used although there are some misgivings as to whether this type of cushion will be entirely satisfactory, the European practice being to lay the plates on a thin layer of about ¼ in. of hot asphalt. The joints between the plates were filled with hot asphalt.

The laying of this test section of cast-iron roadway surfacing developed no serious difficulties. Aside from the special tongs which were used merely for convenience, no special equipment was required. The work was done by the regular city paving crew and because of the larger area of the plates, was accomplished in less time than would have been required for brick or other block type of pavement.

Finished Section of Cast-Iron Roadway Surfacing at Wilmington, Del.

Larger Highway Construction Program Assured

THE largest single Federal appropriation for highways in history is made available by the $4,880,000,000 Emergency Relief Bill passed by the U. S. Senate on April 5 and signed by the President on April 8. The bill provides $800,000,000 for highways and grade crossing elimination.

In addition regular Federal-aid under the Hayden-Cartwright bill of 1934 goes into effect on July 1, 1935, when an appropriation of $125,000,000 becomes available. This sum must be matched by the states, thus making $250,000,000 more for highway construction. There also is $62,000,000 available from previous Federal appropriations and it is expected the states will have around $100,000,000 of their own funds from the gas and motor vehicle taxes which will be used for construction purposes. All in all the money available from these various sources for highway construction purposes sets an all time record for a single year.

There is little question but that construction can be started without any great delay. Early in the year the highway departments of the various states reported that they could begin work immediately on projects estimated to cost $700,000,000. It was further stated that other work estimated to cost $1,000,000,000 could be undertaken within a year. In all 31,925 seperate projects were covered by these reports. Of this total 10,372 projects were for highway construction and reconstruction, 5,326 for replacement of weak and narrow bridges and 4,058 rail-highway grade separations.

The new $800,000,000 appropriation is to be expended under the supervision of the state highway departments and the U. S. Bureau of Public Roads. This large appropriation assures contractors for the first time in several years that there will be highway construction not only tomorrow but also the next day after. In other words they are now assured of a large construction program for at least two years.

The following summary of the new highway legislation is taken from a legislative bulletin of the American Road Builders' Association:

Continues the apportionment of the highway funds to the states in accordance with the Hayden-Cartwright Act.

Apportions the grade crossing elimination funds in proportion to mileage of highways, mileage of railroads and population.

ALLOTMENTS TO STATE BASED UPON THE APPROPRIATION OF $500,000,000 FOR STREETS AND HIGHWAYS, $300,000,000 FOR GRADE CROSSING ELIMINATION

ING ELIMINATION

BASIS OF APPORTIONMENT

State.	"Highway, Roads, Streets" Sec. 204 N. I. R. A. ⅞ Federal Aid ⅛ Population.	"Grade Crossing Elimination." ½ Population. ¼ Miles F. A. Hwy. System. ¼ Miles Railroad.	Total.
Alabama	$ 10,645,000	$ 6,219,000	$ 16,864,000
Arizona	6,590,000	1,956,000	8,546,000
Arkansas	8,595,000	5,493,000	14,088,000
California	19,865,000	11,382,000	31,247,000
Colorado	8,710,000	4,086,000	12,796,000
Connecticut	3,640,000	2,622,000	6,262,000
Delaware	2,310,000	663,000	2,973,000
Florida	6,660,000	4,350,000	11,010,000
Georgia	12,795,000	7,566,000	20,361,000
Idaho	5,700,000	2,610,000	8,310,000
Illinois	22,290,000	15,780,000	38,070,000
Indiana	12,670,000	7,872,000	20,542,000
Iowa	12,800,000	8,595,000	21,395,000
Kansas	12,805,000	7,932,000	20,737,000
Kentucky	9,555,000	5,682,000	15,237,000
Louisiana	7,410,000	4,950,000	12,360,000
Maine	4,300,000	2,202,000	6,502,000
Maryland	4,490,000	3,210,000	7,700,000
Massachusetts	8,365,000	6,330,000	14,695,000
Michigan	16,160,000	10,146,000	26,306,000
Minnesota	13,530,000	8,280,000	21,810,000
Mississippi	8,865,000	5,025,000	13,890,000
Missouri	15,415,000	9,492,000	24,907,000
Montana	9,425,000	4,284,000	13,709,000
Nebraska	9,925,000	5,556,000	15,481,000
Nevada	5,750,000	1,371,000	7,121,000
New Hampshire	2,425,000	1,272,000	3,697,000
New Jersey	8,020,000	6,114,000	14,134,000
New Mexico	7,365,000	2,742,000	10,107,000
New York	28,325,000	20,790,000	49,115,000
North Carolina	12,105,000	7,470,000	19,575,000
North Dakota	7,350,000	5,106,000	12,456,000
Ohio	19,670,000	12,840,000	32,510,000
Oklahoma	11,745,000	7,149,000	18,894,000
Oregon	7,790,000	3,633,000	11,423,000
Pennsylvania	23,965,000	17,703,000	41,668,000
Rhode Island	2,535,000	1,077,000	3,612,000
South Carolina	6,930,000	4,530,000	11,460,000
South Dakota	7,630,000	4,392,000	12,022,000
Tennessee	10,750,000	5,829,000	16,579,000
Texas	30,740,000	16,773,000	47,513,000
Utah	5,305,000	1,923,000	7,228,000
Vermont	2,370,000	1,128,000	3,498,000
Virginia	9,365,000	5,817,000	15,182,000
Washington	7,760,000	4,707,000	12,467,000
West Virginia	5,720,000	4,125,000	9,845,000
Wisconsin	12,370,000	7,734,000	20,104,000
Wyoming	5,690,000	2,178,000	7,868,000
District of Columbia	2,435,000	603,000	3,038,000
Hawaii	2,375,000	711,000	3,086,000
Total	$500,000,000	$300,000,000	$800,000,000

Provides for the expenditures of these funds by state highway departments under the Federal Highway Act of November 9, 1921, as amended, and the Hayden-Cartwright Act of June 18, 1934.

Provides that no part of the funds need be matched by the states.

Provides that the funds shall be spent under Rules and Regulations prescribed by the President. (These undoubtedly will be similar to the Rules and Regulations under the Hayden-Cartwright Act.)

Provides that preference in employment of labor shall be given to persons receiving relief, excepting those in executive, administrative, supervisory and highly skilled positions.

Authorizes the President to predetermine for each state the hours of work and the rates of wages to be paid skilled, intermediate and unskilled labor.

Provides that whenever practicable full advantage shall be taken of the facilities of private enterprise (contract system).

Continues the penalty clause for states diverting motor vehicle and gasoline taxes.

It is generally believed that the appropriation will be split up on the basis of $500,000,000 for highways and $300,000,000 for the elimination of grade crossings. Using these figures as a basis the A. R. B. A. has prepared the accompanying tabulation.

The Highways Appropriation

EIGHT hundred million dollars for highways and grade separations! Once it would have seemed a fabulous sum: today it is a matter for comment but not for marvel. Highway builders and highway users think that Congress did wisely in appropriating this sum—the third largest of the eight groups into which the work relief bill is divided, being exceeded only by the $880,000,000 for direct relief and the $900,000,000 for loans to states and other political subdivisions and topping the entire list so far as specific classes of work are concerned.

One and two generations ago this nation passed through a great railroad building era—an era which, whatever its abuses and inconsistencies, raised us to a condition of unparalleled prosperity and material comfort. We are now in a similar era of highway building, and it is well to recognize the fact definitely: barring catastrophies in other fields, highway expansion will carry us even farther than railway expansion on that never-ending road of progress which it is man's lot to follow.

Highways broaden the view in more than one sense: they open minds as do printing and wire communication and radio. The younger generation of necessity cannot fully sense the change. But let any man past forty recall the mental outlook of most of the older generation he knew as a boy, or think of the disappearance of colloquialisms and the general improvement in the nation's grammar, and he can hardly miss the point.

The government's eight hundred million is intended, of course, to supply work first of all. In no other field can a great number of men be given jobs so quickly, with reasonable assurance that they will produce something of lasting value. But beside the immediate importance of the jobs and the permanent value of the product, is the factor of a public work which will increasingly stimulate and promote other activities—which will contribute to the national welfare far in excess of expenditures made on it.

One great caution must be maintained. The work must be done efficiently. The importance of making jobs must not be an excuse for wastefulness. Every labor saving device, every economical method, must be used, that in return for our $800,000,000 we shall receive the maximum possible mileage of well located, well designed and well constructed roads and grade separations. This great step in the highway building era must not be marred by graft or incompetence. It must be a step in human progress in the truest sense.

▼

A Change in Auto Design

HERE and there on the road is appearing an odd looking vehicle which suggests to some a collie dog with its muzzle chopped off—to others, more mechanically inclined, a change in motor vehicle design which is remarkable only for the slowness of its coming. We refer, of course, to the car with the motor in the rear and the front hood omitted.

The precise necessity for an engine located as far away as possible from the driving wheels has long been a mystery; and now it appears that the reason, whatever it may have been, is passing. It is hardly likely that the change will extend to all classes of vehicles. Most trucks, for example, can not have a power plant which would obstruct rear loading; and only a most radical change in engine design would permit a power plant located underneath the floor. But on second thought, is this limitation necessary? Why not a front loading truck, with the driver perched in the rear in the fashion of the ancient hansom cab? Stranger designs might be made.

We venture the prediction that the rear-motored car is arriving, and that as a result we shall have cheaper, easier operated, more dependable, and generally more satisfactory passenger cars within a very few years. As for the trucks, after having had a few run squarely across our right of way because the drivers knew we were tender hearted and didn't want to smash them; well, we think the trucks can be depended on to take care of themselves.

▼

Spend It Right

NOW that the $4,880,000,000 work relief bill is law the detail of its expenditure assumes first position in our immediate national economy. That there will be much selfish, shameless and unpatriotic grabbing goes without saying. Communities and special interests alike have a childishly happy faculty of seeing their own interests to the exclusion of others; and the Federal administration will be hard put to secure an even approximately reasonable and just distribution. Assuredly it behooves all men of broad views and high principles to fight for fairness—if necessary with a sacrifice of local prestige.

The allocation of the huge sum, as provided in the bill, is as follows:

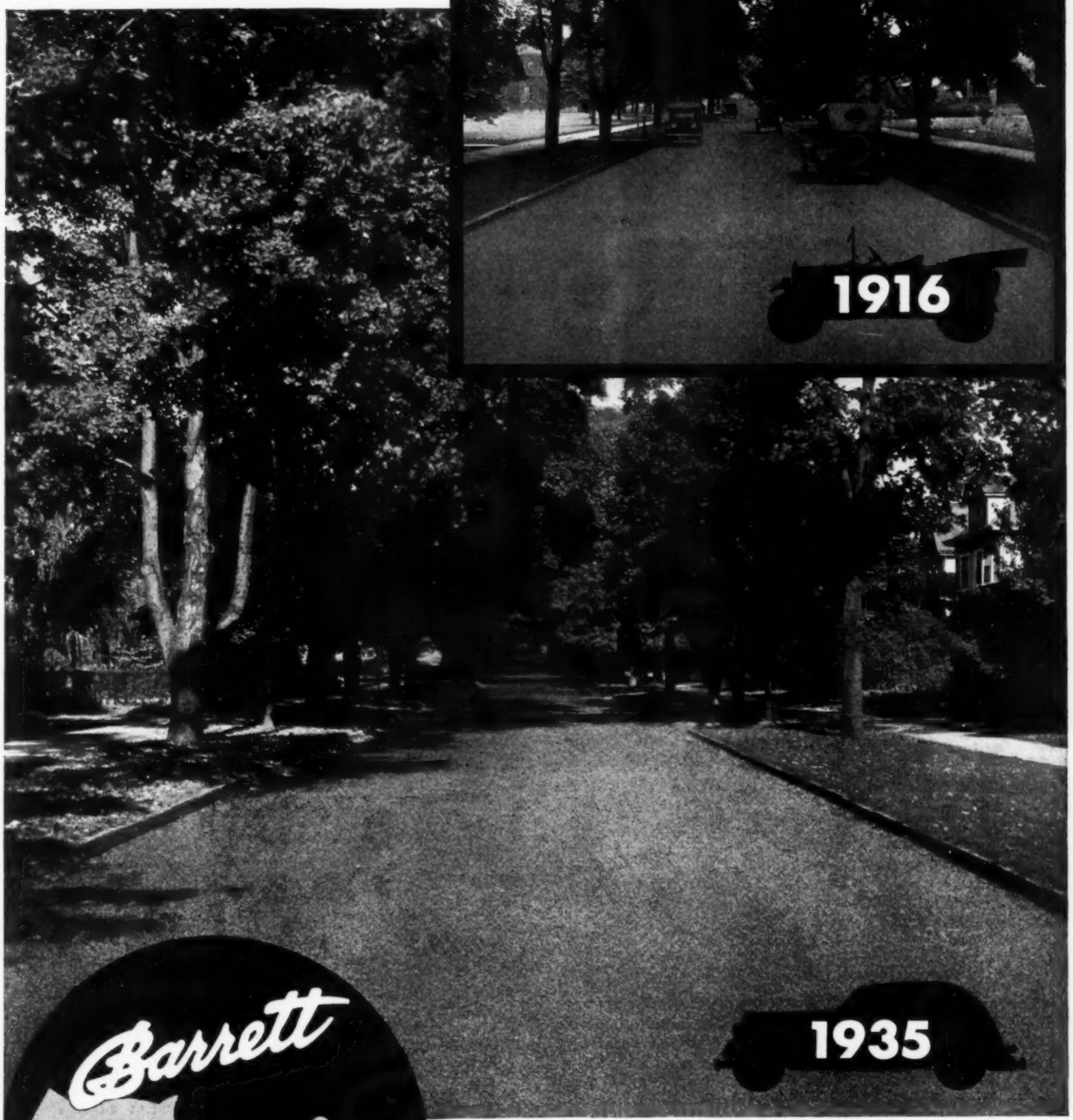
Direct relief pending transfer of some 3,500,000 persons from dole to works employment	$880,000,000
Highways and grade separations	800,000,000
Rural rehabilitation and relief in stricken agricultural areas, water conservation, irrigation, and reclamation	500,000,000
Rural electrification	100,000,000
Housing	450,000,000
Assistance educational, clerical and professional persons	300,000,000
Civilian Conservation Corps	600,000,000
Loans or grants to states, territories, and possessions, including subdivision thereof, where not less than ¼ of the loan or grant or the aggregate thereof is for expenditures for work	900,000,000
Sanitation, prevention of soil erosion, flood control, harbors, and miscellaneous projects	350,000,000

In seeking a proper ultimate disposition of these funds one need not agree as to the wisdom either of the total amount or the foregoing subdivision. The various sums now stand appropriated, and presumably they represent as equitable a distribution as could be got through a very human and correspondingly imperfect Congress. That republicans in the Senate voted 10 to 9 for the measure indicates that its passage was more than a mere steam roller operation.

The sums are to be expended "in the discretion and under the direction of the President," subject to very moderate limitation—the greatest money spending power ever held by one man.

Mr. Roosevelt can be depended on to act wholeheartedly for the national welfare, but with all his power he must have the aggressive support of the good men of all parties, of all business interests, in all parts of the country, if he is to make these billions perform their allotted task of bringing back a fair measure of prosperity and contentment.

Grove Street, Sewickley, Pennsylvania. Tarvia-built in 1916, the year which marked the beginning of Federal Aid road building. Lower photo shows condition of road today.



Barrett

Tarvia

GOOD ROADS AT LOW COST

Tarvia is made by America's oldest and most experienced manufacturer of coal-tar road-building materials. It is refined to rigid specifications which meet every road-building or road-maintaining need and fit every traffic requirement. Grove Street's nineteen years of flawless service—and this is not an exceptional Tarvia performance record—tells you how durable Tarvia roads are, and why Tarvia belongs in your road program. Phone, wire or write for details.

THE BARRETT COMPANY New York Chicago Birmingham Philadelphia St. Louis Minneapolis Hartford Detroit Cleveland Boston Buffalo Columbus Milwaukee Providence Syracuse Lebanon Toledo Cincinnati Baltimore Youngstown Bethlehem Rochester Portland, Me. *In Canada:* THE BARRETT COMPANY, LTD., Montreal, Toronto, Winnipeg, Vancouver

Yes—We would like you to mention ROADS AND STREETS.

NEW EQUIPMENT AND MATERIALS

Rooter for 35 and 50 H.P. Tractors

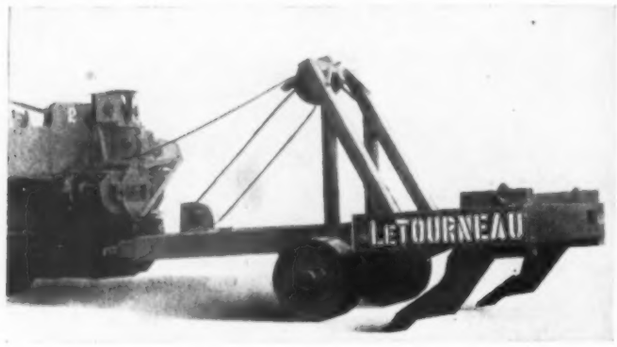
A rooter that may be used with 35 and 50 H.P. power tractors has been placed on the market by R. G. Le Tourneau, Inc., Stockton, Calif., and Peoria, Ill.

The same rugged, all-welded, special steel construction that goes into the larger LeTourneau rooters is used in this smaller size. In general, it follows the same design, but is lightened somewhat to assure efficient use with tractors from 35 to 50 H.P.

It is stated the new unit will handle much of the ripping and scarifying usually handled by larger rooters, and so free large tractors for heavier work.

Specifications of the Type S Rooter are as follows:

Length Over All	13½ feet
Width Over All	75 in.
Number of Standards	3 or 5
Length of Standards Below Frame	20 in.



Le Tourneau Type S Rooter

Distance Between Outside Standard Centers	63 in.
Wheel Diameter	24 in.
Axles	Heat-treated Alloy Steel
Bearings	High-Duty Timkens
Size of Standards	1¾ in. by 10 in.
Wheel Rims	¾ in. by 10 in. Plow Steel
Weight of Standards Without Teeth	173 lbs.
Weight of Standards With Teeth	202 lbs.
Cable Necessary for Operation	45 feet of Le Tourneau ½x6x19
Weight 3 Tooth	4280 lbs
Weight 5 Tooth	4760 lbs.

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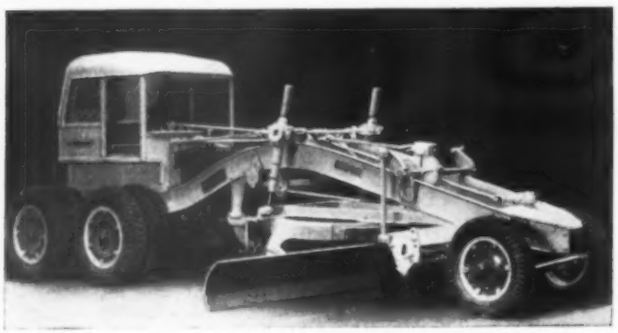
New Road Grader

A new grader having two speed variable control power lift and pivoted spring suspended front end has been brought out by W. A. Riddell Co., Bucyrus, O.

This grader is made in two sizes, so constructed that all standard makes of tractors may be used. Frames for 40 to 50 H.P. tractors will be 10 in. high, weighing 30 lbs per foot and for lighter power a 10 in. frame weighing 25½ lbs. per foot will be used. Frame is a welded rigid frame with five cross braces of tubular and box section construction. All connections are hardened ball joints with machined adjustable bearings.



Rear Controlled Model 35 Road Hog Grader

A two speed variable control power lift is used, which is claimed to give faster movement to the blade, cross shift, circle turning and scarifier at normal R.P.M. of motor or at low throttle. This new power control assembly is grease tight, with drop forged, machined and hardened gears and clutches, operating on ground, splined shafts with replaceable bronze bushings and patented oil seals.

The size of the circle has been increased to a large 61½ in. full circle with adjustable take-up to eliminate all chatter. Moldboard connections to beams are ball and socket construction.

The variable control power lift and spring mounted stabilized front axle is stated to give higher maintenance speed, less chatter and no side whip on the blade.

The cab is a large turret top, roomy cab with adjustable upholstered seat. Grader has a 54-gal. gas tank mounted in rear of cab.

▲

New ½-Yd. Excavator

A new ½-yd. crawler type shovel-crane-dragline for gasoline, diesel or electric operation has been brought out by the American Hoist & Derrick Co., St. Paul, Minn. This Model 350 extends the range of sizes of the "American Gopher" to cover the field from ½-yd., to 2-yd. capacity.

The outstanding features claimed for the Model 350 include the following:

Master control clutch for easy operation; SKF self-aligning ball bearing used on all high speed shafts; high line speed on drums—two travel speeds; swinging speed 5.15 R.P.M.; Tail swing only 8 ft., permitting work in close quarters; splined shafts—all shafts are independently removable; all friction clutch and brake surfaces are cast nickel iron; all steel construction. Machine is easily convertible from shovel to crane or dragline work and vice versa. Two-piece welded dipper sticks; all welded shovel boom; full manganese steel dipper; renewable and reversible tooth points; variable boom radius; independent chain crowd or rope crowd; high speed return; all shafts nickel chromium steel, heat treated.

"American Gopher" Model 350 ½-yd. Shovel

The machine is powered by a Waukesha, 53 H.P., 4-cylinder, 4¾x6¼ engine, complete with electric starting equipment. The weight of Model 350 as a shovel (independent chain crowd) is approximately 32,000 lbs. It has a travel speed of 1.75 miles per hour in high gear and 0.70 miles per hour in low gear.

▼

New Diesel Engine

A new diesel engine has just been placed on the market by the Murphy Diesel Co., Ltd., of Milwaukee, Wis. It is a 5¾x 6½, six cylinder unit, with an economical horsepower range from 100 h.p. to 150 h.p., and may be adapted to all industrial and marine requirements, according to designer M. J. Murphy.

In this engine the fuel pump and nozzle have been combined in a single injector unit which is placed in the center of the cylinder head and surrounded by four valves. This injector unit is actuated directly by two camshafts, one on each side of it, thus forming a balanced drive. Injectors are spring loaded and ride on the cams, hence are always synchronized with the other

HOW NEW TRUCK TIRES END COSTLY ROAD DELAYS AND BREAKDOWNS

AS TOLD BY
Willard D. Jacobson
of Delmar, New York

W. D. Jacobson (standing) and James D. Jacobson of the Willard D. Jacobson and Son Company, Delmar, New York.

"Our six dump trucks are on the go most of the time hauling crushed stone. Our loads are exceptionally heavy so that it's pretty tough work for tires.

"The total mileage in the last year is well over 300,000 miles, yet we did not have a single sidewall failure or delay due to tires.

"All this means a great saving to me as now I do not have costly breakdowns on the job."

Those are the words of Mr. W. D. Jacobson. His experience has been duplicated hundreds of times since Goodrich introduced Triple Protected Silvertowns. You can save, too, with these amazing new tires.

This new invention positively checks 80% of premature failures:

1 PLYFLEX—a *new*, tough, sturdy rubber material with greater resistance to stretch. A layer of Plyflex in the sidewall prevents ply separation—distributes stresses—checks local weakness.

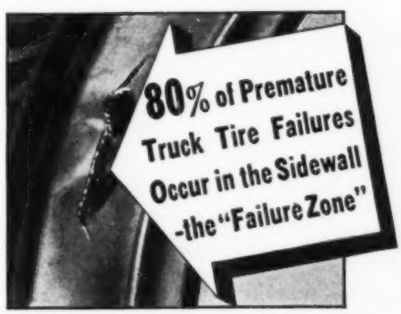
2 PLY-LOCK—the new Goodrich way of *locking* the plies about the bead. Anchoring them in place. Positive protection against the short plies tearing loose above the bead.

3 100% FULL-FLOATING CORD—Each cord is surrounded by rubber. With ordinary cross-woven fabric, when the cords touch each other, they rub—get hot—break. In Silvertowns, there are no cross cords. No friction.

Don't take our word for it. Try a set on a job that's really a tire-killer. Prove to your own satisfaction that Triple Protection will save you money. You don't pay one cent extra for the extra service you are bound to get.

FREE! 44-PAGE HANDBOOK FOR TRUCK OPERATORS

Every truck owner, every driver should have this big 44-page handbook. Gives commodity weights, tire load capacities, inflation schedules, dual spacing chart, load analysis and other useful information. No obligation. Write for free copy. Dept. T-47, The B.F. Goodrich Company, Akron, Ohio.



Goodrich *Triple Protected* Silvertowns

SPECIFY THESE NEW SILVERTOWN TIRES FOR TRUCKS AND BUSES

SERVICISED

SERVICISED
LOOK FOR IT ON ALL PURCHASES

Servicised Cork Rubber Expansion Joint

EXPANSION JOINTS
CORK BOARD
METAL CUSHION JOINT
ASPHALT PLANK (Standard)
MINERAL SURFACED PLANK
CEMENT TREAD PLANK
WATERPROOFINGS
COURSE ROOFINGS

Servicised Sponge Rubber

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Servicised Quality Products have been sold throughout the United States for upwards of 13 years. Thousands of installations attest the recognition and approval accorded them by State Highway Departments and Engineers.

Our products find ready acceptance and our distributors are given wholehearted cooperation in their sales efforts,

Servicised Felt Reinforced Joint

for despite adverse economic conditions, there has been no let-down in the high standard of quality established when our first product was introduced.

Inquiries will receive prompt attention. Write today.

Servicised Type "B" Joint

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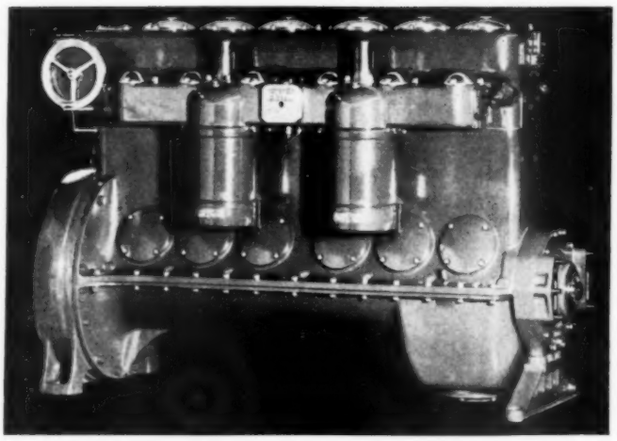


New MD-6 Diesel Engine

functions of the engine. Oil is delivered to injectors under 10 lbs. pressure, in excess of maximum demands, surplus oil being returned to the fuel tank.

Other features of the new MD Diesel are: Gasoline starting with this auxiliary fuel burned within its own combustion chambers; oil-tight and dust-tight construction; improved cooling and lubrication system with water pump and oil pump mounted directly on the crankshaft where positive operation is assured, combined with temperature control that holds Lube oil and cooling water within 20 deg. F., of each other; oil bath Donaldson-type air cleaners built into the inlet manifold to form an integral part of engine; centrifugal, flyball type governor accurately controlling an hydraulic servo motor, which permits control of speed variations from full load to no load, or vice versa, within less than 1 per cent.

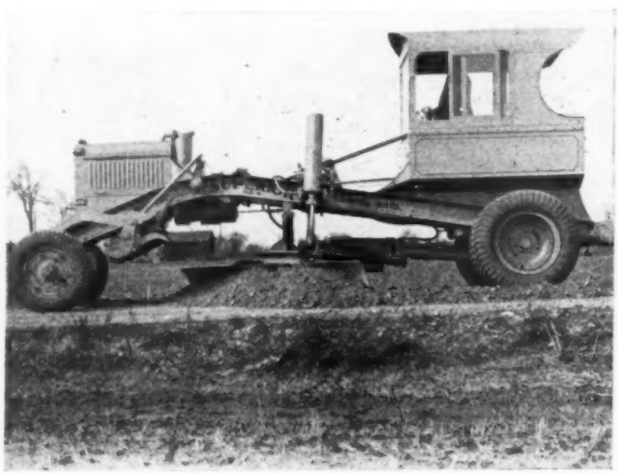
The first engine off the production line is the MD-6 (100 H.P. to 150 H.P. practical power range for continuous operation). This will be made available for all power uses, to be followed later by the smaller engines.

▼

New Motor Grader

A Motor Grader in which many new features of design are incorporated is announced by the Huber Manufacturing Company of Marion, O. The new Huber "Superior No. 4" model has the engine mounted towards the front of frame, the power being transmitted to rear axle assembly through a shaft, similar to the method employed in heavy truck construction. The blade is pushed, bull dozer style, by a heavy tube attached direct to rear axle housing.

The maker claims this design gives a better balanced grader with more traction and less liability to side slip—that it leaves the entire wheel base available for proper positioning of the blade and that it provides a flexibility hitherto unapproached in a motor grader and greatly broadens its field of usefulness. It



"Superior No. 4" Motor Grader

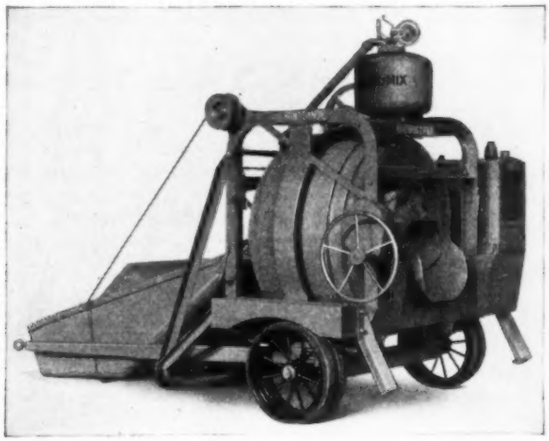
is stated the blade may be used in any position, right or left, from straight across to horizontal with frame and that it will ditch on either right or left side without changing position of blade on the hangers. It has a side shift of 36 in. and a blade clearance of about 18 in. when fully raised.

Some other features are: Heavy duty six cylinder engine; folding scarifier—when scarifier is raised it automatically folds up completely out of the way of all grader operations; dual steering—hand and power steering instantly interchangeable; differential lock—pressure on foot pedal locks differential to make it inoperative when necessary; direct connected hydraulic control that eliminates chatter; five forward and two reverse speeds ranging from less than a mile to nearly 20 miles per hour; five point hydraulic control, etc.

Officials of the Huber Company state that tests of this new type grader carried on for the past two years have proven so satisfactory that all other model graders previously made by this concern will be discontinued and manufacture concentrated on the "Superior No. 4." It is now available in the 12,000 lb. class but both smaller and larger sizes are being developed.

New 14-S Mixer

The new 14-S Dandie Trail-Mix is the latest development in a complete new line of Koehring Dandie Construction Mixers, which have been developed within the last 12 months by the Koehring Co., Milwaukee, Wis.



New 14-S Dandie Trail-Mix

The outstanding feature of this machine is the low weight of 5100 lb. and the narrow width of 90 in. It is equipped with Koehring automatic skip flow shaker, which causes the material to be shaken in a direct flow line of the skip. Full spring mounting, multiple "V" belt drive, automatic water tank, self leveling skip, are a few of the many features of this modern concrete mixer. The charging skip is free from obstruction at the front or sides, which permits fast and easy charging directly into the skip without hindrance.

New 3/8-Yd. Excavator

A new full-revolving 3/8-yard excavator, known as The Model 100, Bantam Weight, is announced by the Harnischfeger Corporation of Milwaukee. Weighing approximately 15,800 lbs., this new machine is fully convertible.

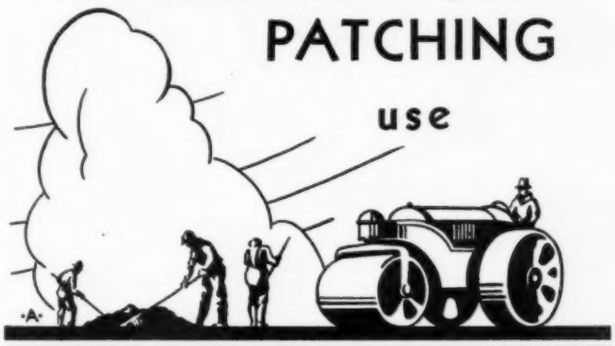
Fast operation has been the keynote in the design of the Model 100 with travel speeds from 1½ to 3 miles per hour combined with easy steering, climbing and quick turning ability. Standard swing speed is 5 R.P.M. with P.&H. split second clutches for easy control, fast starting and stopping and quick spotting of the dipper. Live boom chain crowd mechanism permits booming up and down without changing length of chain.

Easy convertibility is a feature of the new machine. All welded fabrication has not only reduced weight, but has also increased structural strength. The revolving frame and side stands, for example, are a single piece, combining automotive box and X frame in one solid welded structure. The boom is also of light welded tube construction.

NOW AVAILABLE

For SPRING COLD PATCHING

use



"Central" Asphalt EMULSION

1. LOW COST. "Central" Emulsion is even cheaper than substitutes inferior in quality.

2. MAY BE USED COLD. Fluid at any temperature above freezing, its fluidity does not change with the temperature as is the case with other bituminous products. The winter grade is not affected by temperatures down to 20 degrees below zero. Freezing does not impair its efficiency.

3. USABLE ON MOIST SURFACE OR DAMP STONE. It is the only bituminous material which will mix readily with and bond firmly to damp stone.

4. SETS QUICKLY. Rate of setting can be suited to requirements. Does not "kick out" under traffic or "push" in hot weather. Does not have to be cured, but can either be piled or used immediately after mixing.

5. EASILY HANDLED. May be mixed by hand or in concrete mixer. Spreads easily in cold or hot weather.

6. SAFE AND PLEASANT. Non-inflammable and odorless.

7. DOES NOT PICK UP OR TRACK IN. Its quick setting permits its use on roads where heavy traffic would scatter other cold mix materials. Emulsion is the only bituminous material which can be used cold for paint or skin patching or for sealing road surfaces, and which will not "pick up" immediately after application.

New England Representative
E. Beach Smith
800 Statler Bldg.
Boston, Mass.

COLUMBUS CLEVELAND CENTRAL Emulsions KANSAS CITY BALTIMORE

Virginia Representative
Eastern Building Supply Co., Inc.
214 Builders Exchange
Richmond, Virginia

The CENTRAL OIL EMULSION CORP.
OF DELAWARE
P. O. Box 1417 Baltimore, Md.

New "Bantam Weight" Excavator

The machine is powered by the Ford V-8 truck motor delivering 40 H.P. at 1300 R.P.M. and with other main machinery units, it is placed behind the center of rotation to reduce dead counterweight. Diesel power is also available.

Standard tractor links are used so that replacements can be made with the least possible loss of time. Standard shoes are 10 in. wide, although provision has been made for 18-in. links where extremely low ground pressure is desired.

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Moves Its Office

The Copper & Brass Research Association announces the removal of its office as of April 1, 1935, from 25 Broadway to 420 Lexington Ave., New York.

WITH THE MANUFACTURERS

Reading Iron Company Announces Changes

W. S. Shiffer, general manager of sales of the Reading Iron Co., has announced that S. H. Blackwood, formerly assistant district sales representative in the New York territory, has been made district sales representative in southern territory with headquarters at 1104 Continental Bldg., Baltimore, Md. Mr. Blackwood takes the position held for many years by W. J. White, who recently resigned. W. N. Johnson has been appointed as salesman in the New York territory.

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Joins Sales Force of Caterpillar Tractor Co.

Frank E. Blanchard, formerly manager of sales, southeastern states, for the Climax Engineering Co., of Clinton, Ia., has joined Caterpillar Tractor Co. at Peoria, Ill., as a member of the special sales department. Mr. Blanchard has been connected with the Climax Co. in sales executive capacity for about 9½ years. Mr. Blanchard also served as assistant chief engineer and sales engineer in the industrial division of the Buda Co., Harvey, Ill. He has had wide experience in engine sales and engineering fields.

▼

Bucyrus-Erie Moves New York Office

On April 4, the New York Office of Bucyrus-Erie Co. was moved to new quarters on the 36th floor of the RCA Building in Rockefeller Center. Working out of this office, in addition to Eastern Sales Manager, J. C. Alexander, are: R. W. Conant, F. Leslie Jones, W. W. Goetz, E. G. Lewis, R. J. Breslin, G. E. Peterson, G. L. Harman, and T. A. Billings. The new telephone number will be Columbus 5-4395. Bucyrus-Erie Company, manufacturers of excavating, drilling and material handling equipment, have their general offices at South Milwaukee, Wis.

▼

UP GO PROFITS! DOWN GO COSTS!

LeTOURNEAU

EQUIPMENT

(Left) Broadway Low Level Tunnel approach highway job near Oakland, California. (Above) Improving the Rimway Highway around Crater Lake, Oregon.

This job proves it. 72 cu. yds. per hour per scraper . . . 1600-foot round trip . . . favorable grades of 38 to 40% . . . loading in clay and decomposed rock . . . that's what these 5 LeTourneau Carryall Scrapers (left) are moving.

LeTourneau Angledozers (above) move 100 cu. yds. per hour right along.

Ask for DATA SHEET PROOF—Write us, describing your problems; our Engineering Department will gladly send you Data Sheets telling how LeTourneau Equipment has licked similar problems for others.

R. G. LeTOURNEAU, INC.

Peoria, Illinois Cable address "Bobletorno" **Stockton, California**

When writing to advertisers please mention ROADS AND STREETS—Thank you.

Atlas Supply New Distributor for Toncan

Appointment of Atlas Supply Co., Inc., 35-39 Woodward Ave., Brooklyn, N. Y., as warehouse distributors of rust-resisting Toncan iron sheets has been announced by N. J. Clarke, vice-president in charge of sales, Republic Steel Corp., Youngstown, O. A complete stock of sheets will be maintained by the new distributor, forming still another link in the nation-wide chain of distributors of Republic's Toncan iron.

▼

Le Tourneau Opens Branch Factory at Peoria, Ill.

R. G. Le Tourneau, Inc., Stockton, Calif., announces the opening, April 1, of a factory branch at Peoria, Ill., to handle the constantly growing demand in the East, South and Middle West for Le Tourneau equipment. A full stock of Le Tourneau units and parts will be available at the new plant and, effective at that time, Peoria f.o.b. list prices will be the same as the Stockton f.o.b. list. A staff of field engineers and service men, specially selected for their knowledge of contractors' problems, will work out of the new office.

▼

Albert C. Lehman Elected Chairman Board of Directors of Blaw-Knox

Directors of Blaw-Knox Co., Pittsburgh, Pa., at their organization meeting March 29, created the office of chairman of the board. Albert C. Lehman, president, was elected to the new post in appreciation of his 30 years of service to the company since its inception, a resolution of the board stated.

Irvin F. Lehman, vice-president, who has also been associated with the company since its early days, was elected president, and Frank Cordes was made senior vice-president.

The following were re-elected: Chester H. Lehman, vice-president; Robert F. McCloskey, vice-president; George L. Dumbauld, treasurer; H. B. Loxterman, secretary; B. L. Hirshfield, chairman finance committee; Paul W. Keim, assistant treasurer; H. S. Strassburger, assistant treasurer and assistant secretary; P. A. McCullough, comptroller.

Pierce Governor Co. Building Addition to Plant

The Pierce Governor Co. of Anderson, Ind., is building a new addition to their plant to meet demand for their Bear rollers. In the first sixty days of 1935 they booked orders for three times as many rollers as for the entire year 1934.

▼

Republic Steel Moves New York District Sales Office

Effective May 1, the New York District Sales Office of Republic Steel Corporation will be removed to the Chrysler Building, according to an announcement by N. J. Clarke, Vice President in Charge of Sales for Republic. W. H. Oliver continues in charge of the office as District Sales Manager. Republic's Export Department, under the direction of D. H. Bellamore, General Export Manager, will also occupy a portion of Republic's new suite in the Chrysler Building.

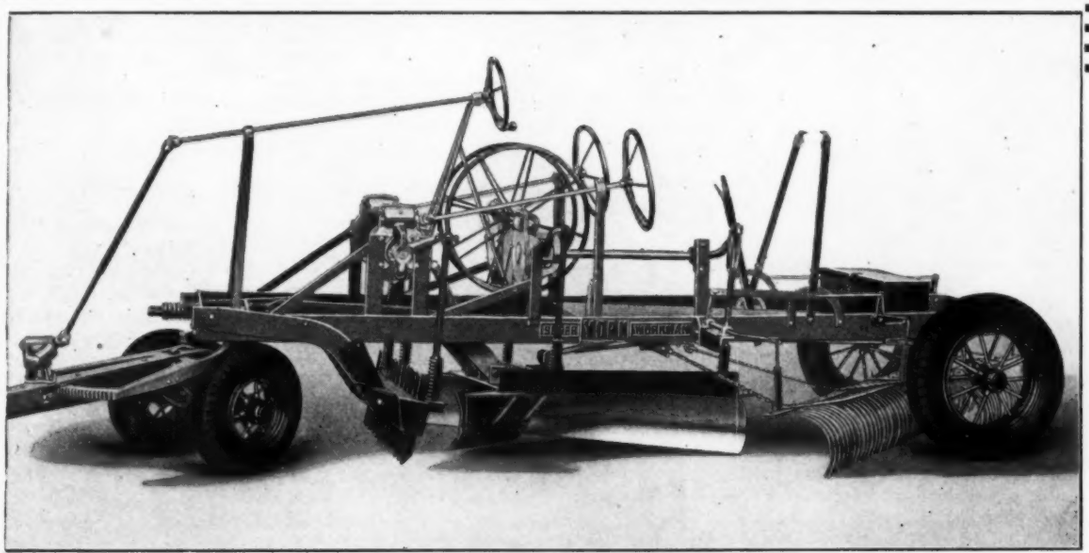
▼

McCoy Now Director of du Pont Co.

John W. McCoy, general manager of the explosives department of the du Pont Company, has been elected a member of the company's board of directors and has also been made a vice-president and member of the executive committee. Edward B. Yancey succeeds him as general manager of the explosives department.

Mr. McCoy has been connected with the company since 1902 when he joined it as a chemist in the Repauno plant of the high explosives department. Since that time he has served continuously in a number of the company's plants in various parts of the country, in addition to making a tour of duty in Mexico. He has served as general manager of the department since August, 1929.

Mr. Yancey joined the du Pont Company as a chemist 27 years ago and has been continuously identified with the explosives department during that entire time. In 1928 he became assistant director of the manufacturing division and a year later became assistant general manager, which position he has continued to hold until his appointment to the general managership.



THE YORK SUPER WORKMAN

A Sturdy, Well Built, Balanced, Maintainer, capable of the most efficient and satisfactory type of Road Maintenance. Investigate this unique machine and learn how Better Roads can be built at less expense—The unusual Scarifier—efficient Blades—Remarkable Rake—All working together make the York Super Workman an ideal Maintainer.

YORK MODERN CORPORATION
UNADILLA, NEW YORK

Carpenter Now With "Caterpillar" Sales Department

J. W. Carpenter, Jr., of Meridian, Miss., has joined the sales department of Caterpillar Tractor Co. to assist with its erosion control program. Mr. Carpenter for the last nine months has served as chief agricultural engineer for the U. S. Department of the Interior in the Mississippi area. Prior to this service Mr. Carpenter was extension agricultural engineer at Oklahoma A. & M. College. His work in the field through that state was chiefly in connection with erosion control, farm buildings and farm drainage. He is a graduate of Mississippi State College, later taught there six years and had charge of agricultural engineering work for the experimental station of the state for a year. He served five years as county agent. From 1914 to 1917 he was agricultural engineer for the state of Mississippi. Mr. Carpenter has had 20 years' active experience in the soil reclamation field, and is regarded as an authority on terracing and allied problems.

▼

Blaw-Knox Wins Patent Litigation

The Blaw-Knox Co., Pittsburgh, Pa., was granted a perpetual injunction against the Koppel Industrial Car & Equipment Co. recently by Judge Nelson McVicar in United States district court restraining the car and equipment concern from further infringements of a patent on wall mold apparatus.

The litigation has been in the Federal courts for several years and recently the circuit court of appeals upheld a decision handed down by Judge McVicar. In his decree, Judge McVicar said no accounting was ordered because the court had been informed the parties have agreed on the sums to be paid by the Koppel company to the Blaw-Knox concern.

▼

Ray L. Howes Joins Worthington

As a result of increased activity in its diesel and gas engine lines, the Worthington Pump and Machinery Corporation, Harrison, N. J., has found it advisable to further amplify the supervision of business in these lines in its eastern district—and to that end has created the Eastern Oil Power Division under the field management of Ray L. Howes, with headquarters at its New York Office, No. 2 Park Avenue.

Mr. Howes is widely known in the diesel engine world and has had extensive experience in its various fields of application.

He was educated at Iowa State College. Prior to his college course he spent several years in the shops of the C. & N. W. Railway. Subsequently he was with the Peoples Gas Light and Coke Company of Chicago, on power plant and gas engine test and research work. He later was with the Studebaker Corporation of Detroit, leaving there to join the faculty of the Mechanical Engineering Department of the University of Pennsylvania. For the past 22 years, he has been connected with the Diesel Sales Division of the Fairbanks-Morse Company, at St. Louis and Chicago.

Through the Corporation's field organization in the territories of the District Offices of Boston, New York, Philadelphia, Washington and Atlanta, Mr. Howes will have supervision of diesel engine sales in these office territories.

▼

FWD Establishes Dealership in Syria

The Four Wheel Drive Auto Co., of Clintonville, Wis., and Kitchener, Ont., has established a dealership in Syria. The new dealer is an exporter and importer of renown in western Asia. He was winner of the gold medal, for those activities, at the Paris International Colonial Exposition in 1931.

C. S. Thompson, foreign sales manager for the FWD Co., reports that the roads in Syria are fairly good, and the distances short. There is one positive exception to both of these observations; that is the trans-desert traffic. There the distances are long and there are no roads.

These extreme contrasts in conditions result in extreme contrasts in types of cars used. Thus the two most popular FWD trucks in Syria represent the extremes of the FWD line; one the HS, the lightest truck the company makes, and the other the MX6, a huge six-wheeler, with drive power on all six wheels, the largest model of the FWD regular series. The MX6 proved its trustworthiness on the great Iraq pipe line project in Palestine as a dependable "camel of the desert."

On account of desert dangers, Syria is very strict in the enforcement of load regulations. Overload is guarded against constantly. When a vehicle is offered for licensing, it is put onto a scale and weighed; the difference between the total vehicle weight, empty, and gross capacity, declared right then and there, is made available for pay-load and that pay-load restriction is scrupulously enforced.

▼

Tarbell Joins Ideal

Ray P. Tarbell was recently appointed manager of the welding division of the Ideal Electric & Manufacturing Co., of Mansfield, O. Mr. Tarbell has been in the welding industry and its development since 1918, 17 years. This includes 13 years with the Lincoln Electric Co. as sales engineer and district manager, two years with Robt. E. Kinkead, Inc., consulting welding engineers, and two years as manager of welding electrode division of Babcock & Wilcox Co. As manager of the welding division at Ideal, Mr. Tarbell will have charge of merchandising the new Noel "Speed Arc" welder.

▼

Changes in Management of Robert W. Hunt Co.

Robert W. Hunt Company, Engineers, conducting a national and international engineering inspection, testing, and consultation service, with general offices in Chicago, has accepted the resignation of C. B. Nolte, their President who has accepted the Presidency of Crane Company.

James C. Ogden, formerly Vice-President, in charge of Robert W. Hunt Company's eastern and foreign activities at New York, will suceed Mr. Nolte as President. Mr. Ogden has been actively engaged with the organization for the past thirty-five years and in an executive capacity since 1908. Mr. Ogden is a member of the American Society of Civil Engineers, the Engineers' Club of New York, the American Society for Testing Materials, various other engineering organizations and the Plainfield Country Club.

Mr. Ogden will be ably assisted in the operation of the organization by F. M. Randlett, as Vice-President and General Manager. Mr. Randlett has been Pacific Coast Manager of the company at San Francisco since 1926 and prior to that was Chief Engineer of the Water Department of Portland, Ore. Mr. Randlett is a member of the American Society of Civil Engineers, the American Water Works Association, the American Society for Testing Materials, the Engineers' Club of San Francisco and various other engineering organizations.

Robert W. Hunt Company was organized by Captain Robert W. Hunt and associates in 1888.

▼

Federal Motor Truck Celebrates 25th Anniversary

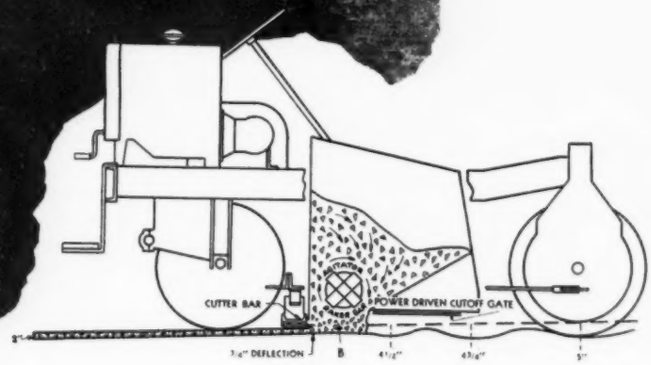
The Federal Motor Truck Co. of Detroit has just celebrated its silver anniversary. On this occasion Federal executives, employes and dealers paid tribute to Martin L. Pulcher, president of the company, who enjoys the unique distinction of being the directing head of a motor truck company for a quarter of a century. Mr. Pulcher's experience in the automotive industry dates back 29 years when he was one of the incorporators and secretary-treasurer of the Oakland Motor Car Co.

The Federal Motor Truck Co. was incorporated under the laws of the state of Michigan on Feb. 14, 1910. Among the founders of the company were M. L. Pulcher, Edward P. Hammond, T. E. Reeder, C. F. Mellish, E. A. Skae, Charles Baird, Edwin Denby, J. Walter Drake and E. R. Staughton.

Some idea of the growth of the company can be gained by a comparison of the small original plant containing about 5,000 sq. ft. of floor space with the modern truck factory occupied by Federal today which covers eight and one-half acres and comprises more than 500,000 sq. ft. of floor space.

As already mentioned, the management of the company has been guided during the entire 25-year period of its existence by Martin L. Pulcher. R. W. Ruddon, vice-president, secretary and general manager has been with the company since 1914, and C. A. Rogers, treasurer, has also served the company for over 20 years. Other executive officers include J. F. Bowman, vice-president in charge of sales; Hal H. Smith, vice-president, and Francis J. Ferguson, assistant secretary. The present board of directors includes M. L. Pulcher, R. W. Ruddon, Hal H. Smith, Edward P. Hammond, Dr. W. E. Rice, Frank H. Whelden, C. A. Rogers, George de Bienville Keim and J. F. Bowman.

A GAUGE THAT INSURES BLACK TOP ACCURACY

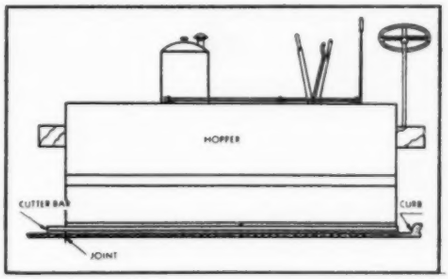


THERE are only three ways to secure absolute accuracy of Surface on your Black Top Pavement. Either the machine must travel on a perfectly finished subgrade, on carefully laid forms or finished shoulders or travel on the finished pavement.

The Adnun Black Top Paver brings you the proved accuracy that comes with traveling on the finished pavement. There is no need for forms or finished shoulders, no need for a perfect subgrade, no need for springs to correct the mistakes the paver is making—the finished pavement furnishes an accurate template that insures a perfect road.

The Adnun Paver has been proved in four years of actual service. It brings you features that are exclusive advantages—the Two-Speed Cutter Bar, the Power Cut-Off, the Quick Lift. These are decided assets in securing better pavement in less time.

Before you buy be sure you investigate the Adnun Method of paving—and ask about these Adnun advantages.



The top diagram above shows an Adnun Paver on an exaggerated grade. Assuming a course of 2", the front wheel will be seen to have dropped into a 3" hole. Even in this extreme case the deflection of the cutter bar is only ¾".

On even an average subgrade a hole the unusual depth of ¼" would deflect the cutter bar 1/16 of an inch on the first course and this would be corrected to 1/32 of an inch on the second course. The Adnun Method corrects imperfections where with other methods—once a hollow always a hollow.

The diagram below shows how the cutter bar overlaps and makes the joint.

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World's largest exclusive builders of road pavers.

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ADNUN

TRADE MARK REGISTERED

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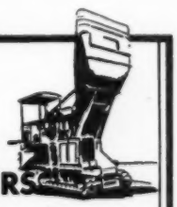

FOOTE ENGINEERS have kept pace with concrete road problems. The MultiFoote Paver is absolutely up to the minute—the latest thing in concrete pavers. When you are in the market ask about its 10 points of superiority.

ROADS AND STREETS

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WRITE for our new circular showing illustration and description of Olsen Special Bench Type Compression Testing Machine. It is designed especially for testing 2" x 4" cylinders and 2" x 2" cubes. The machine is hydraulic, having two gauges, one to half and the other to full capacity. Capacity ranges of from 20,000 to 80,000 lbs.
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